Power and The Engineer

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PAGES of engineering articles are written concerning the operating details of power-house equipment. Difficulties likely to arise in the management of every conceivable piece of apparatus are thoroughly discussed and plans outlined looking to the best mode of procedure under certain assumed conditions. This is right and proper and much valuable information originally known to the few is thus disseminated for the use of the many.

In all this discussion it is a notable fact that mention is hardly ever made of the most important single factor in power-house operation—the management of the men who do the actual work in the plant.

It is well known that a machine is easier to handle than the man who handles the machine. Every piece of apparatus has certain characteristics which must be mastered before successful operation will be possible, but once mastered these characteristics are invariable, and may be depended upon to manifest themselves in an orderly, regular manner.

On the other hand, the operative is composed of a bundle of unknown and variable characteristics which require a thousand-fold more study and cultivation to master, but which will repay the effort many times over, for just as the superior personnel and training of an army will cause it to triumph even with inferior equipment, so will a well managed force of operators produce better results in an engine or boiler room.

A man who is forced to do his duty merely through fear of discharge will not do those many little contributory things which make for the most successful result as a whole,—things he would willingly do if through different management the spirit of faithful cooperation was instilled into him.

It is surprising how little thought is given to this important subject. Each case, seemingly, is left to take care of itself according to the personal peculiarities of the man in charge. The question ordinarily is realized more keenly by the man in the subordinate position than by the man responsible for the operation of the plant, while from the standpoint of increased efficiency the situation really should be reversed.

A chief engineer, on being offered the management of another plant, will ask as his first question, "What kind of equipment have they got?"—thinking that if the equipment is to his liking and adapted to the service, he can get results regardless of other conditions.

An oiler on being offered a job in another power house will say, "What kind of a man will I have to work for?" The oiler *knows* that he can get along with the machinery, whatever the type, but before letting go of his old position, takes good care to inform himself as to the possibility of permanent and congenial employment with his new boss.

The proper method of handling men is not taught in schools or books. It must be learned by close observation and study of each individual case, but its importance in producing maximum results cannot be overestimated.

Government Plant at Washington

By F. L. Johnson

This plant is probably the most elaborate and modern central power, light and heating station in the world. Four 2000-kilowatt turbine generating units are installed for a maximum load of 1500 kilowatts. Steam for heating and cooking is carried more than a mile, and water for condensing nearly as far.

For some years a central power, lighting and heating station for the United States Capitol, the Congressional Library and the proposed Senate and House of Representatives office buildings had been considered, with the result that about two years ago the plant now nearing completion was begun.

It was decided to locate the power house at Garfield Park about one-half mile south of the Capitol and seven-eighths of a mile north of the eastern branch of the Potomac river from which the condensing water is drawn.

Built of rough brick and covered with stucco, the power house with its red-tiled roof, graceful outlines and windows, wide and high, presents a pleasing appearance. In the foreground is the boiler house, 160x87 feet, with its chimneys of radial brick, each 11 feet in diameter and extending 200 feet above the grates.

Boiler-room Equipment

In the boiler room are sixteen 600-horsepower Atlas water-tube boilers arranged in batteries of two on each side of the central firing aisle 26 feet wide and which is in keeping with the generous use of floor space wherever passageways are required, the narrowest aisle between the boiler settings and the nearest wall being six feet. As will be seen from the floor plan, the boiler room in the direction of its length is at right angles to the length of the turbine room giving the best possible layout and most direct system of piping.

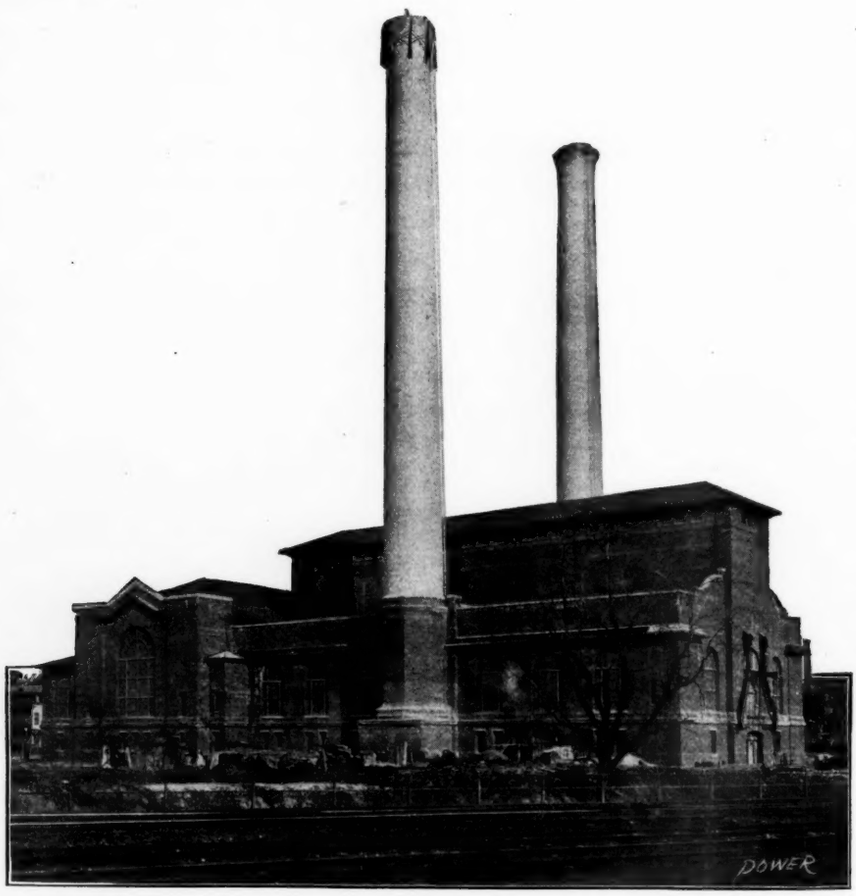


Fig. 1. Exterior View of Power Plant

For feeding the boilers there are three compound-duplex, outside-packed, plunger pumps with suction connections to the condenser hotwells and to the city water supply. Any two of these pumps are of ample capacity to supply all of the boilers with water at the highest possible rate of evaporation, and in addition to each boiler is attached an injector of sufficient capacity to supply feed water under the severest conditions of overload.

Coal is landed from standard railway cars into track, hopper scales from which it goes, by means of apron feeders, to the crushers, and thence by the way of a vertical bucket conveyer to the storage bunker in the monitor where it is distributed by a belt conveyer with adjustable automatic tripping mcehanism. From the bunker, which has a holding capacity of about 1600 tons, the coal is delivered by gravity to measuring hoppers and through spouts and spreaders to the Roney stokers with which the boilers are equipped.

Underneath the stokers are the ash hoppers for catching and holding all ashes until dumped into the special, steel ash cars running on tracks in the basement to the double-skip, automatic, ash hoist, which carries them to an overhead storage bin from which they are delivered to railway cars through spouts.

Generators

In the turbine room are four Westinghouse turbine generators, each of 2000 kilowatts, rating with a 37½-kilowatt exciter coupled to an extension of the generator shaft. Each turbine is connected to two Bulkley injector, barometric condensers designed to maintain a 28-inch vacuum at full generator load without the use of dry-vacuum pumps.

Water for condensation is supplied from the eastern branch of the Potomac river, seven-eighths of a mile from the power house and 58 feet below the level of the condensers.

Pumping Station

Built of brick with a red-tile roof, and resting on a substantial foundation of concrete-capped piling, 200 feet from the shore, is the pump house designed for three 20-inch, submerged, centrifugal pumps, each directly connected by a vertical shaft to a 250-horsepower, 25-cycle, three-phase, 6300-volt, six-pole motor running at 480 revolutions per minute. The motors are located on the pump-house floor above the high-water level, while the pumps are below the low-water mark.

As each of the pumps is installed in a separate chamber, connected to the main

intake by a short passage with the sluice gate operated from the pump-house floor, any one of the chambers may be closed and pumped dry at any time when inspection is desired or repairs necessary. For emptying the chambers, there is a 2½-inch, direct-connected, submerged, centrifugal pump running at 705 revolutions per minute, with the inlet so piped that any of the three chambers may be emptied independently of the others. From the pump to the power house a 36-inch cast-iron force main is laid, two weights of pipe being used; the lighter extends from the power house to a point about half way to the pumps and the heavier, subjected to the higher pressure due to the increased head, extends the rest of the way.

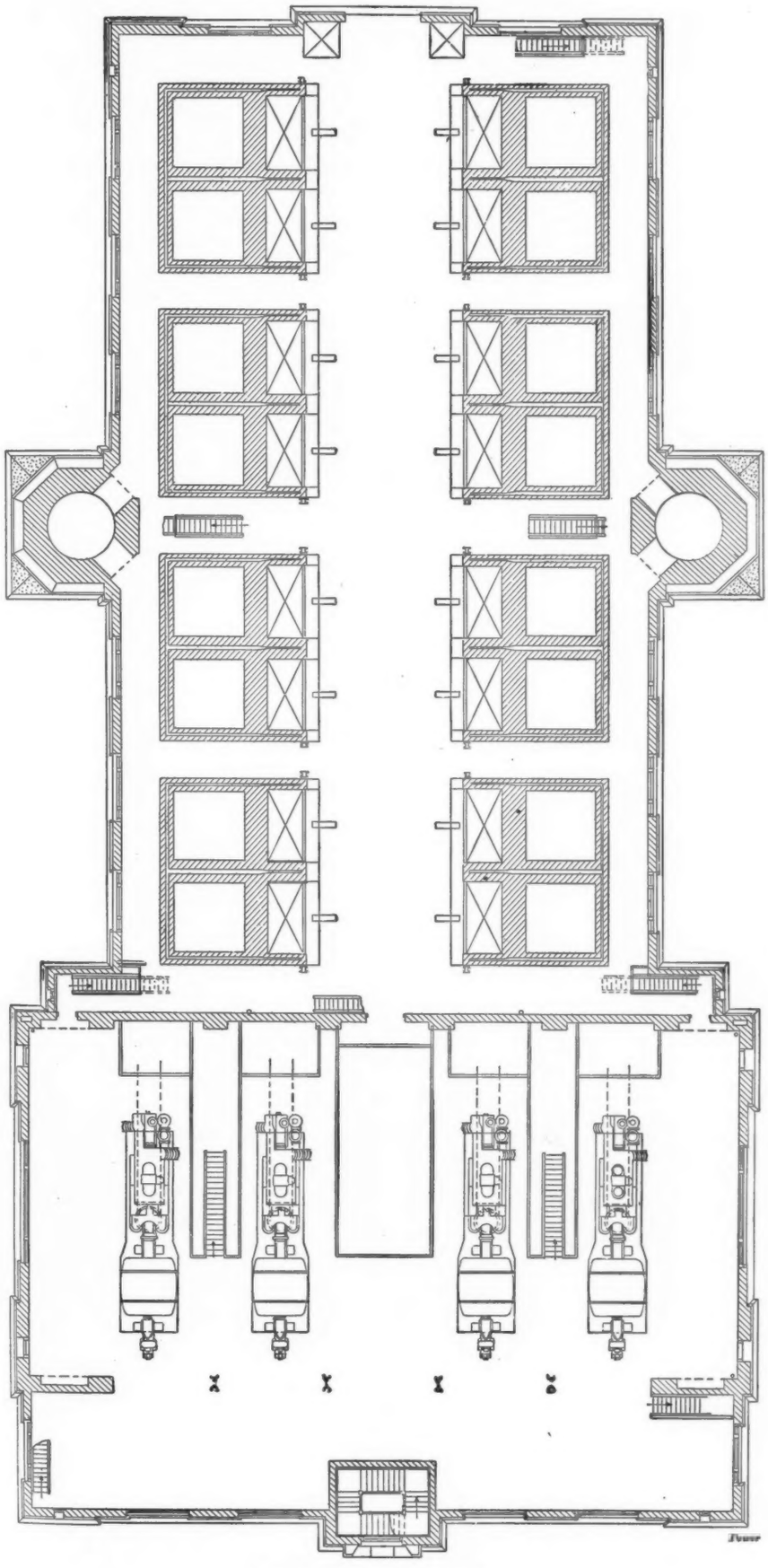


FIG. 2. PLAN OF STATION

From the pump house to the shore there extends a reinforced-concrete trestle work carrying the 36-inch bell-and-spigot force main, the power and light electric cables and a roadway.

For the greater part of the distance from the power house to the river a concrete conduit 48 inches in diameter, for the return of the condensing water to the river, is laid in the same trench with the supply main, leaving it at a point near the shore line and discharging below the intake.

Logs, floodwood, trash, leaves, grass and ice are kept out of the intake by booms, racks and screens which may be expeditiously handled by the aid of overhead trolleys carrying chain hoists.

STEAM DISTRIBUTION

Steam for cooking, laundry and heating purposes is furnished to the four Capitol buildings through a 14-inch pipe, laid in a tunnel of reinforced concrete 7 feet in hight and 4 feet 6 inches in width, furnished at frequent intervals with special manholes suitable for the handling of sections of pipe 22 feet long, and between these are smaller manholes for ventilation, admission and exit. The 14-inch steam pipe is supported on a heavy structural-steel pipe rack fitted for an additional 14-inch steam pipe and for drip and water piping.

Expansion is taken care of by specially designed slip joints and roller-pipe supports. The piping will stand full boiler pressure and has pressure-reducing valves at the power-house end and at each of the buildings, permitting the regulation of pressure in any desirable way. The tunnels connecting the power house with the four buildings have a total length of over 6200 feet. From some of the buildings the condensation will be returned to the boilers, while from others, where the tunnel is low, it will be trapped to the sewer.

SUBSTATIONS

There are 15 substation distributing units each comprising a 400-kilowatt, 125-volt, direct-current generator coupled to a synchronous alternating-current motor running at 500 revolutions per minute. In the Capitol there are five of these units, four in the House of Representatives office building and three in both

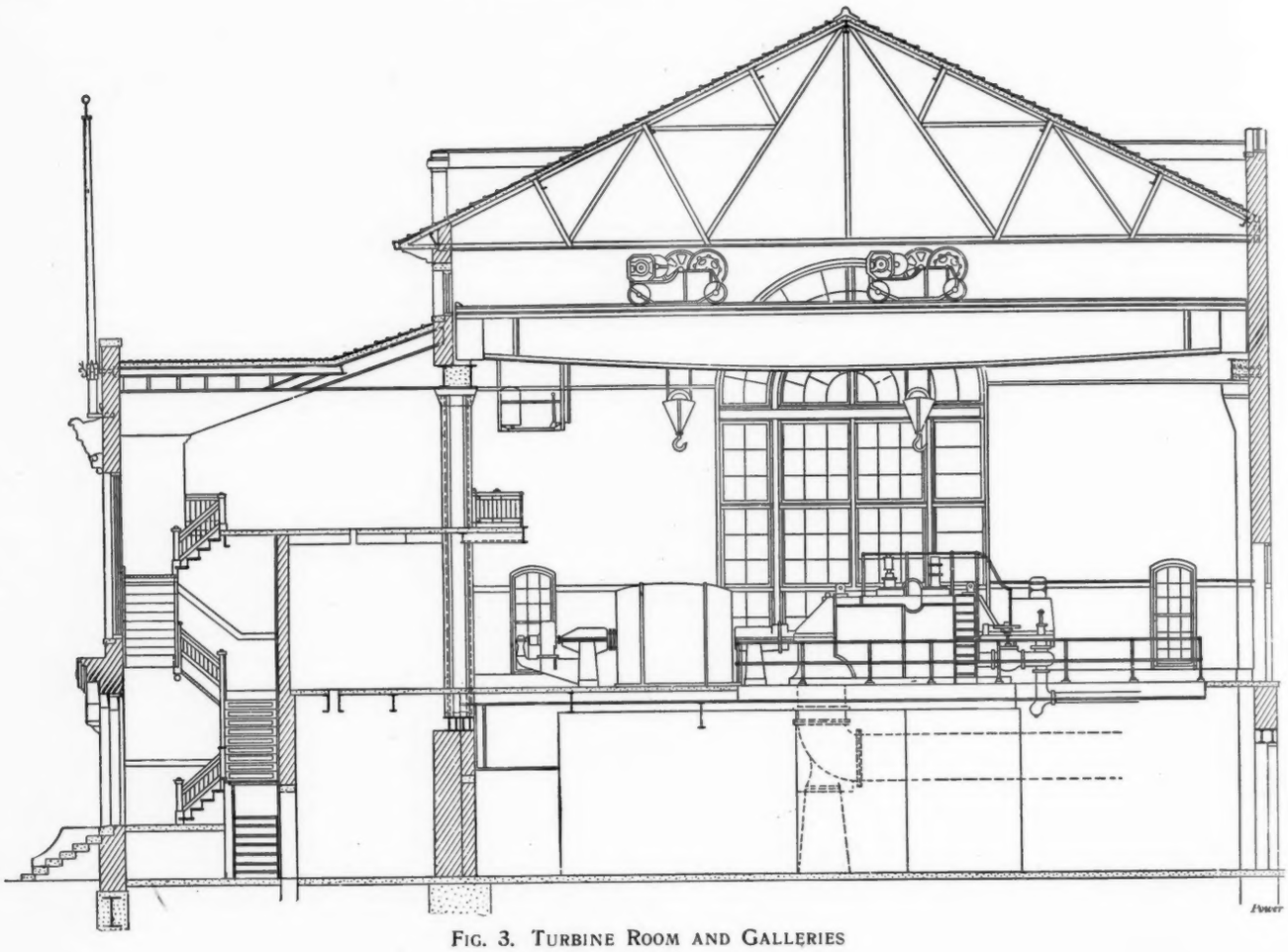


FIG. 3. TURBINE ROOM AND GALLERIES

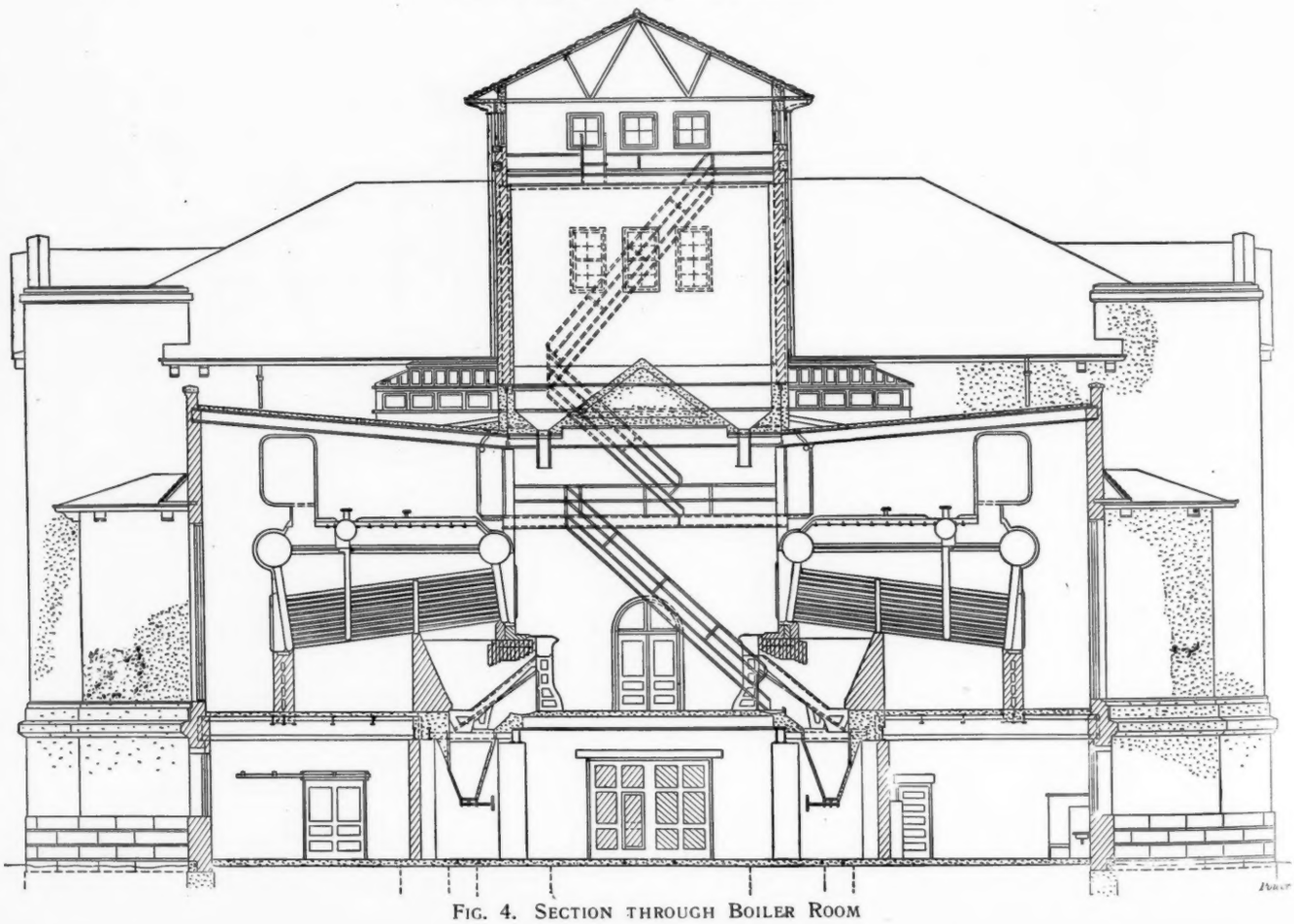


FIG. 4. SECTION THROUGH BOILER ROOM

the Senate office building and the Congressional library.

All of the motors are so connected that they may be started by the alternating current, by direct current or by an alternating-current, direct-connected induction motor. Each substation has two direct- and two alternating-current starting equipments, each of which is capable of starting five sets in succession.

Each substation is connected to the power house by four-way, vitrified-tile ducts laid in concrete and provided with manholes at suitable intervals.

Two, three-conductor, paper-insluated, lead-sheathed cables lead to each substation, each of sufficient capacity to transmit the amount of current needed by the substation under full load.

There are emergency lamps in all of the substations, tunnels and in the pump house supplied with current from the storage battery by two-conductor, paper-insulated, lead-covered cables, which can be lighted when necessary by means of the no-voltage switches installed for the purpose.

Miscellaneous Equipment

At one side of the turbine room are the switchboard gallery and the electrical controlling apparatus, while in the basement is the storage battery of 800 ampere-hours capacity.

In the various departments convenient

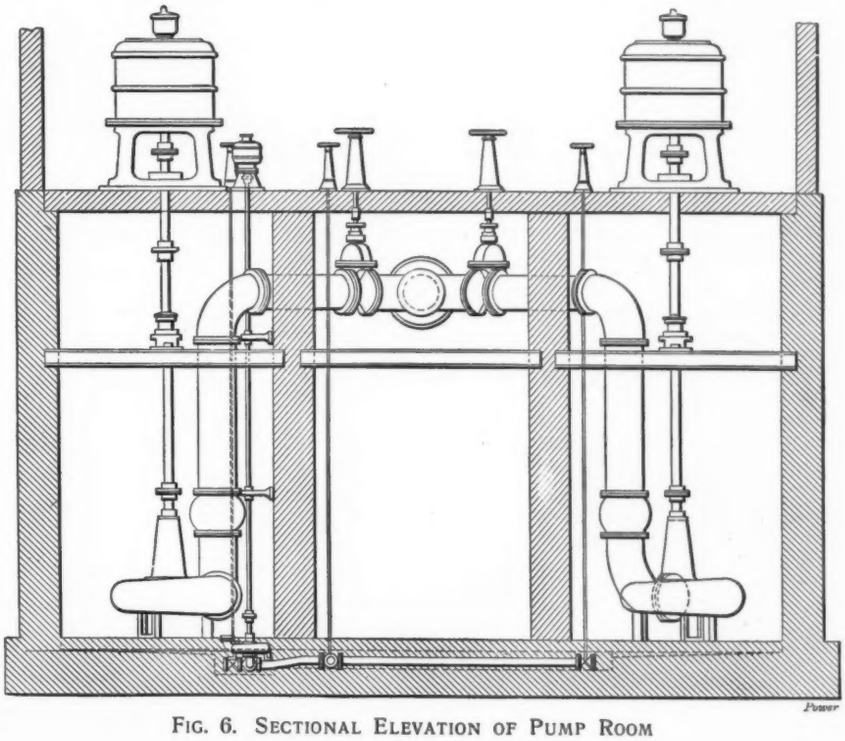


Fig. 6. Sectional Elevation of Pump Room

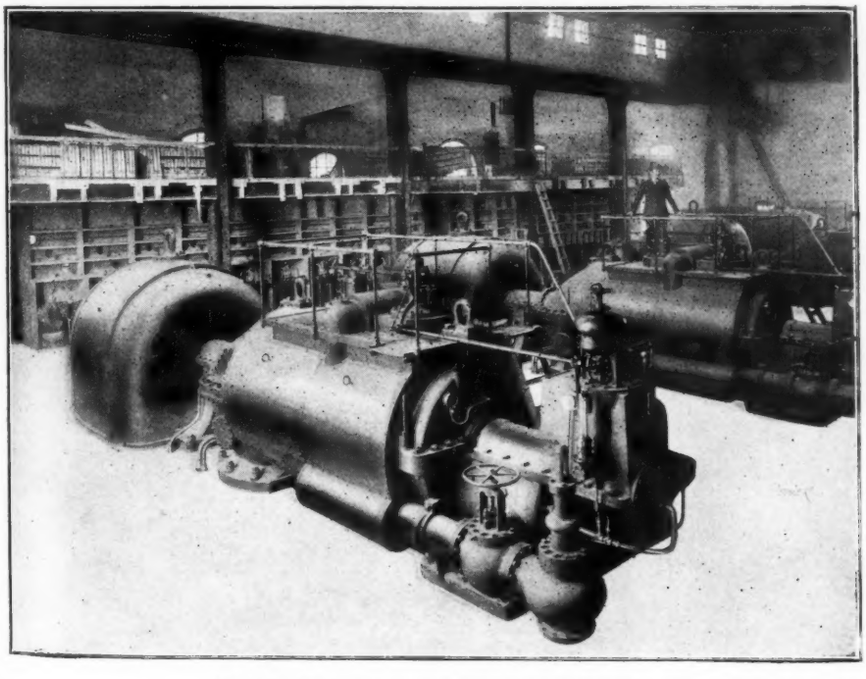


Fig. 5. Two of the Generating Units

of access are lockers, tool, toilet and store rooms and offices for superintendent and staff.

The boilers were furnished and installed by the Atlas Engine Works, the electrical equipment and all construction not previously contracted for by the Westinghouse Electric and Manufacturing Company, and the foundations of the power and pump houses and the concrete trestle and bulkhead by Cranford Paving Company. Westinghouse, Church, Kerr & Co., were retained as engineers after the fundamental determination as to size, etc., had been made by the Government engineers. No central power, light and heating plant was ever more complete with respect to precautions taken to prevent the possibility of a failure in continuity of its service.

It has been said by some that the plant is elaborate to a ridiculous and extravagaint degree and of a capacity more than three times greater than that which will ever be needed and that many installations are unwarranted by the existing conditions.

This latter contention is given a shade of justification by the installation of four 2000-kilowatt generators for a service which in the opinion of many who claim to know will never exceed 1500 kilowatts; the elaborate starting equipment in the substations the whole of which no probable combination of accident and demand will call into service; a double set of transmission cables where a single set of much less costly construction would be used in commercial construction and operation, and the storage battery installed and maintained for the problematical demand of a few emergency lamps when connections to outside commercial lines is both cheap and convenient.

About a year ago it was reported in Washington that a local corporation was ready to furnish all the light and power needed by the Government for an annual payment of 3 per cent. on cost of the new plant, which would mean a saving of the entire cost of operation. In fact, there is in some quarters an impression that the entire project has been manipulated by the politicians in this manner for the pure purpose of discrediting the idea that public ownership and operation of power, heat and lighting plants is in the line of good practice.

The plant is elaborate, it is complete and has cost several times the amount of the original estimate; but whether the criticisms are just or otherwise only time will determine.

Locomotive Boiler Explosion

By S. A. Johnson

Nine men were killed in the explosion which was laid to over pressure due to the steam gage, and possibly the safety valves, being out of order.

At 3:05 o'clock Saturday morning, April 16, a locomotive boiler of the National Lines of Mexico exploded in the railroad yards at Monterey, killing nine men, including the engineer and the night foreman of the roundhouse, and seriously injuring two others.

It is generally believed that the cause of the explosion was excessive pressure, as it is known that the steam gage, and perhaps the safety valves also, were out of order and that a machinist was trying to adjust the safety valves at the time of the explosion.

The engine had been ordered to take out a freight train at 3:30 a.m., and was run out of the roundhouse by the hostler to the coal bins; while being coaled up, the safety valves began to blow off with the steam gage showing less than 50 pounds pressure, when it should have indicated 175 pounds. When the engineer saw this state of affairs, he reported it to the roundhouse foreman and refused to take the engine out until it had been put in order; the engine was then placed on a side track near the roundhouse and the foreman with a crew of machinists and helpers began working to get things in order, and from all reports they were screwing down on the safety valves. As all who were very near the locomotive at the time were killed, it is almost impossible to learn exactly what was going on when the explosion occurred.

There are many conflicting reports regarding the matter. One is that the safety valves were reported out of order when the engine was placed in the roundhouse and had been ground in the day before, but not adjusted, being left for adjustment when steam was raised on the boiler. This is given as the reason for working on the safety valves instead of the steam gage.

The entire firebox end of the boiler was blown off, shearing the double row of rivets where it was riveted to the main part of the boiler. The crown sheet was torn across in a jagged line, leaving a part of it attached to the flue sheet. That part of the crown sheet which was torn loose, together with the back end of the firebox, were thrown directly backward

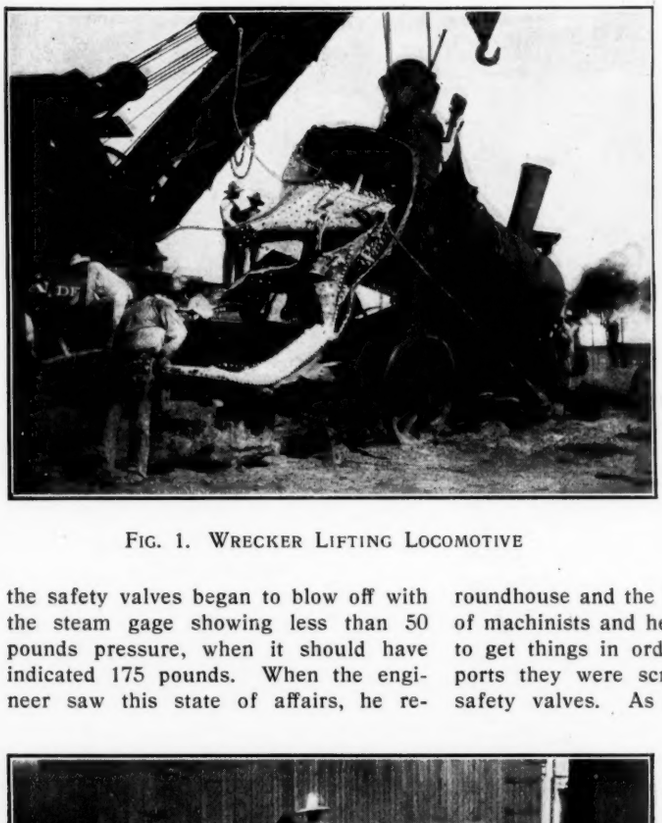


FIG. 1. WRECKER LIFTING LOCOMOTIVE

FIG. 2. REAR PART OF FIREBOX AND PART OF CROWN SHEET

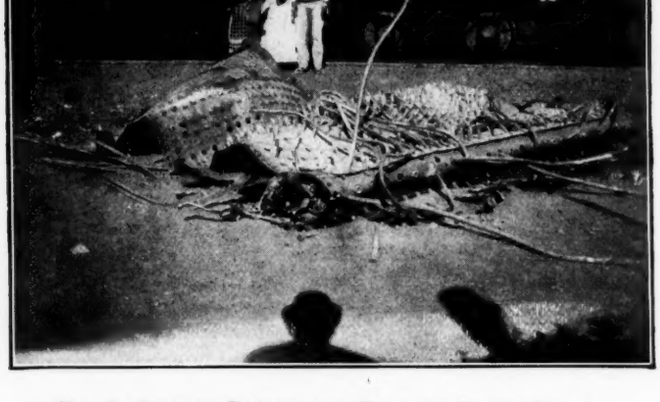


FIG. 3. FIREBOX PROPER AND PART OF OUTER SHELL

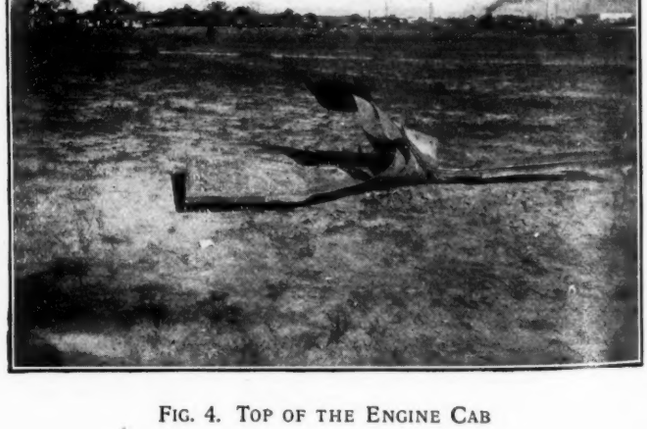


FIG. 4. TOP OF THE ENGINE CAB

about 80 yards. The remainder of the firebox and outer shell were thrown over the top of the engine and landed near the track about 100 yards in front of where the locomotive stood. The top of the cab and reverse lever were found 175 yards to the right of the track, the body of the hostler, who was in the engineer's seat at the time of the explosion, was found near the reverse lever. The engine frame was spread outward, forcing the rear drivers off the axles, bending the axles and almost completely wrecking the engine. The locomotive proper did not leave the track, but moved ahead about 50 feet.

The crown sheet and firebox plates appear to have been in good order and show no sign of having been burned, but few of the staybolts were broken and all of them look as though they were in good condition, with the exception of the threads being stripped where they were pulled out of the fire sheets.

The boiler was of the enlarged firebox type and was built in 1897 by the Brooks Locomotive Works.

The photographs were made 12 hours after the explosion. Fig. 1 shows the locomotive with the wrecker lifting it up. Fig. 2 shows the rear part of the firebox and a part of the crown sheet. Fig. 3 shows the firebox proper and a part of the outer shell, and Fig. 4 shows the top of the engine cab at some little distance from the track.

Combustion in Boiler Furnaces

By J. F. Springer

In perfect combustion carbon and oxygen unite in certain definite proportions to form carbon dioxide (CO_2). With too little oxygen in the furnace, or if the gases come in contact with a cooling surface before they unite, the combustion is incomplete and carbon monoxide (CO) is formed. The author uses oil-lamp examples to explain the action of the gases and shows how the combinations formed are duplicated in the furnace of a boiler.

Just what do we mean by combustion? When an oil lamp is burning, we say that combustion of the oil is taking place. When a splinter is lit and a more or less bright flame results, accompanied by smoke, we say that combustion of the wood is going on. If we inquire of the chemists as to what is taking place, they will tell us that the material which we say is burning is being broken up, and that the oxygen in the air is combining chemically with its particles. In consequence of this combination, heat and light become manifest. This is what is ordinarily termed combustion. But a visible flame is not essential. What is essential is the chemical combination and the consequent evolution of heat. When we breathe, combustion takes place. Air is taken into the lungs where it is brought into contact with blood which has become laden with impurities. A chemical breaking up takes place resulting in carbon from the blood uniting chemically with oxygen from the air. When we exhale, the combination passes off as carbon dioxide, CO_2, and more or less heat is evolved. Apart from the spectacular bright flame, this is just what occurs in a furnace. Carbon set free from the coal unites with oxygen from the atmosphere and so forms CO_2 which passes out and up the chimney. Oxygen is eager to combine with hydrogen, sulphur and other substances as well as with carbon whenever the opportunity is offered. In any case, we call the process combustion.

Insufficient Oxygen Causes Waste

It sometimes happens that there is not enough oxygen available to result in the formation of carbon dioxide. Imperfect combustion then results. That is to say, carbon and oxygen unite and form carbon monoxide, CO. You see, only half as much oxygen is required to form CO as is required for CO_2. This may not seem important at first sight, but it is quite so. Carbon monoxide is a poisonous gas while carbon dioxide is merely a suffocating gas. But this is by no means all. The heat evolved when CO is formed is much less than when the complete combustion to CO_2 is effected. When one pound of carbon unites with sufficient oxygen to form carbon monoxide, 4400 heat units result. If, however, a pound of carbon is supplied with enough oxygen to result in the formation of carbon dioxide, 14,500 thermal units are produced. That is to say, if air is supplied in sufficient quantity we shall obtain, instead of a poisonous gas, one which is of advantage to the vegetable world, and more than three times the amount of heat. When hydrogen combines with oxygen, forming water, there is a tremendous production of heat, for the burning of one pound of hydrogen results in 62,000 B.t.u. One pound of sulphur unites with oxygen to form SO_2 and liberates 4000 B.t.u.

When we supply insufficient air and obtain merely CO instead of CO_2 from the combustion of one pound of carbon, we have lost in heat units the difference between 14,500 and 4400. That is, there have been wasted 10,100 B.t.u., enough heat to raise the temperature of 101 pounds of water 100 degrees Fahrenheit. Of course, it may cost something to supply the extra oxygen under suitable conditions, but allowing for this, there is still an enormous loss entailed when only incomplete combustion takes place.

Oxygen Is Necessary

It is instructive to remember that in endeavoring to secure heat by the process of combustion, nothing will take the place of the oxygen. If we supply a furnace with too little air, so that we are only getting CO with a limited amount of heat, we can correct the difficulty only by supplying the necessary amount of oxygen. To conduct the CO over a highly heated bed of coals with the hope of burning it to CO_2 through the agency of the high temperature without adding more oxygen, is absurd. This will become clear when we consider the two symbols, CO and CO_2. There is just twice as much oxygen indicated by one as by the other. Heat is not oxygen, so it cannot, of itself, cause CO to become CO_2. There is no substitute; sufficient oxygen must be present in order that complete combustion may take place.

It is the same if that which is being separated from the fuel and being burned is hydrogen, or a compound of hydrogen and carbon, instead of simple carbon. The result of the burning or combustion will be heat. Heat is what we want. In order to get it, we must supply oxygen. If we do this, and other conditions are right, heat will be developed in great quantity.

The great difference between anthracite and bituminous coals is that the former coal contains little or no hydrogen (in combination with carbon) while the latter has a very considerable percentage. If bituminous coal be heated without a supply of air, there will be given off one or more of the hydrocarbons such as methane (marsh gas, CH_4), ethylene (olefiant gas, C_2H_4) and acetylene (C_2H_2). A great deal of heat is lost when such gases are allowed to pass out of the chimney. But if sufficient oxygen is supplied and other conditions are right, the carbon atoms will separate from the hydrogen atoms, the carbon will unite with the oxygen to form carbon dioxide (CO_2) and the hydrogen will combine with the oxygen to form water

(H_2O). This is perfect combustion. These chemical changes will produce a great amount of heat. Nothing can adequately take the place of oxygen, so if we want the best results, we must supply it in sufficient quantities.*

Oil Lamp Examples

Consider the illustration furnished by the ordinary oil lamp. Turn up a lighted wick to a certain point. There is no smoke and no bad odor. Turn it up somewhat further and there is smoke and a disagreeable odor. In the former case hydrocarbon is given off, no doubt, just as in the latter; but in the one the air supply is sufficient to furnish the hydrogen and carbon with as much oxygen as they can combine with. The results are water and carbon dioxide. But in the second case the oxygen supply is insufficient and, despite the high temperature, the hydrocarbon passes off to be chilled and to cause an evil smell and black smoke. The introduction into the flame of a cool rod causes a deposit of soot to form upon it. The checking of the combustion of the hydrocarbon exhalation by a lowering of the temperature results in only the hydrogen combining with the oxygen, while the carbon refuses so to combine and separates as soot. In further illustration of the part which the temperature plays, we may take another example. A lamp which is burning perfectly may be made to smoke by raising the chimney and admitting cool air at the bottom.

We may supply a sufficient total amount of oxygen, we may have the temperature sufficiently high, and we may still fail to get perfect combustion. Each atom of carbon needs two atoms of oxygen and a proper temperature. But of what avail are the atoms of oxygen and the heat if these oxygen atoms are not on the spot? That is to say, to get perfect combustion, the oxygen supply must be distributed thoroughly. The want of this is the controlling reason why a bonfire smokes. There is the whole ocean of air with its inexhaustible supply of oxygen but it is not where it is wanted. So with a furnace; it is not enough that a sufficient total of air be introduced, and that a sufficiently high temperature be maintained, the air must be thoroughly mixed with the hydrocarbons as they pass off from the fuel.

In order to understand combustion and successful stoking, it is necessary to understand the functions of three factors:

(1) Oxygen.
(2) Temperature.
(3) Mixture.

*It is true that sulphur, if present, may combine with hydrogen to form sulphureted hydrogen in case of an insufficient supply of oxygen, and no doubt this chemical combination produces heat. However, as the authors of "Smoke Prevention and Fuel Economy" point out, if sufficient oxygen be available, the sulphureted hydrogen may burn to SO_2 and H_2O.

Colorless but Wasteful Smoke

Some additional remarks may be added as to the detection of imperfect combustion. First, if the stack smokes, we know that a quantity of carbon has failed to combine with oxygen, as it is usually the carbon that makes the exhalation from the stack visible. The failure of the chemical combination means that combustion, with its valuable attendant disengagement of heat, has not taken place. Second, if carbon monoxide (CO) is being emitted from the stack, we know at once that not sufficient oxygen is combining with the carbon. Imperfect combustion is taking place. Since carbon monoxide is colorless, we may have imperfect combustion going on and no visible signs of the fact at the mouth of the stack. The stack may be smokeless and the combustion anything but perfect. On the other hand, a given fuel will produce, when completely burned, a pretty definite quantity of waste gases, and that the carbon dioxide ought to constitute a certain definite amount. And further, whether a larger or smaller quantity of fuel be burnt, the ratio of the CO_2 ought always to be the same. So there is a very good reason why we seek to determine this ratio. When the ratio remains constant from hour to hour as the boiler is now pressed and now relieved, it indicates a regularity of combustion.

A great thing to remember in connection with chemical combinations is that they require time for their consummation. This time is usually so short that we are apt to neglect its consideration altogether. For example, the coal gives up its hydrocarbons, a sufficient heat is at hand for ignition, sufficient oxygen is being supplied, and finally there is an adequate mixing operation going on. Will combustion take place? Indeed it will, for all the necessary conditions have been complied with. Yes, it will burn, unless, of course, some change takes place before the combustion has been fully completed.

What we want is combustion at such a location that the heat evolved will be communicated to the boiler surface. However, we do not want to transfer quite all the heat to the boiler, even if we could, for then we should have no draft. The heat necessary for the purpose of securing a draft and thus getting rid of the products of combustion is not great. Therefore, we are free to transfer nearly all to the boiler surface, if we can. It is obvious that heat, being derived from combustion, is not available until the moment of chemical combination. It may be available subsequently, but it cannot be available before. Hence, if the boiler is so placed with reference to the grate that the speed of the rising gases is sufficient to carry a portion of them past the boiler before the combination with oxygen has actually taken place, heat will have been wasted. Not that heat is not generated. It may be liberated, especially if we disregard any chilling surfaces, but at the wrong point. The stack is heated and the outside air is heated, but what we wanted to heat was the boiler. If the gases reach the surface to be heated just after combustion, we may expect little or no loss of heat. It is important, then, to be sure that there is a sufficient distance between the grates and the boiler. If the boiler is such that it may be heated at a number of points, then the gases may be guided to these, distances being so regulated that when at last the gases leave, combustion will have fully taken place.

Temperature of Boiler Surface

A further consideration in connection with our subject concerns the temperature of the boiler surface. Insofar as the thermometer is concerned, this may be taken as about 350 degrees Fahrenheit, or less. It may, therefore, be regarded as a cooling surface as compared with the burning gases. Now if we recollect the effect of a cool rod introduced into the flame of a lamp, we will perhaps better understand the significance of the statement that the comparatively cool boiler must not be allowed to check combustion that is still going on. Gases about to unite with oxygen and so liberate heat will fail to do so if just at the critical moment they and the oxygen have their temperatures lowered. So here is an additional reason for having a considerable distance between the bed of coals and the boiler surface. Combustion should take place before the cool surface is reached. Once there, it may not take place at all, on account of the temperature falling below the ignition point.

It will be seen, then, that it is a matter of importance where we place our boiler with reference to the grate. It is probably impossible at present to define a relation with a comprehensive rule applicable to all cases. There are too many factors entering into the problem. It is sufficient just now, if we realize the importance of the correct placing of boiler and grate.

In some metallurgical operations steam is admitted to large vats or tanks for the purpose of agitating, and, in some cases, heating their contents. In special cases, the consumption of steam for this purpose is enormous, the reduction of which is often possible with better results by mixing air with steam. This may be accomplished by using an ordinary injector. To insure the proper working of the device, the steam is first turned on, then the valve of the injector gradually opened until the desired amount of air is obtained.—*Ex.*

Regulation of Mixed Flow Turbines

By L. Battu

It is becoming common practice to install low-pressure turbines to utilize the exhaust steam from reciprocating engines. This has led to many new features in design. In plants where the conditions are such that the reciprocating engines are intermittently shut down for short periods, a regenerator will take care of the steam for the turbine. But where the engines must be shut down for periods over five or six minutes, it is necessary to operate the turbine direct from the boiler. Efficiency demands the use of mixed-flow turbines in such cases. The design of these turbines is considered and the methods of regulation.

The extensive use of low-pressure turbines utilizing the exhaust of reciprocating engines has brought about features in steam-turbine design which allow a turbine to be run on either low-pressure or high-pressure steam.

The demand for turbines utilizing high- as well as low-pressure steam is due to the fact that plants in which low-pressure turbines are installed sometimes shut down their reciprocating engines and the power required from the low-pressure turbines remains quite independent of the load on the reciprocating engines.

Some years ago, Professor Rateau, by his invention of the steam regenerator, provided means to utilize the exhaust steam from engines operating under variable load conditions, or operating with starts and stops, such as rolling-mill and hoisting engines. The principal function of the regenerator is to absorb the heat contained in the steam when the exhaust of the intermittent engine is in excess of the amount of steam required by the turbine and to restore this accumulated heat in the form of steam when the amount of steam delivered by the reciprocating engine is inadequate to the demand.

It is quite evident that steam regenerators have a commercial limit as to their heat-storage capacity. Plants are being operated with Rateau steam regenerators capable of taking care of loads of several thousand kilowatts during complete stoppages of the reciprocating engines ranging from five to six minutes, with variations in exhaust pressure not exceeding three to four pounds.

Regenerators of commercial size regulate all variations in the exhaust of mill engines during the mill cycle; in other words, the period during which the ingots are rolled. When mills are waiting for steel or when repairs to the rolls or engine are being made, the operation of the low-pressure turbine must remain independent, and therefore the low-pressure turbine must receive steam direct from the boilers, this being accomplished by means of a reducing valve or by direct admission of boiler steam to the turbine, the latter being adapted to automatically utilize steam at high and low pressures.

Obviously, any type of mixed-flow turbine—or in other words, turbines utilizing steam from sources at different pressures—can effect a saving by the use of the steam regenerator, as the special function of the regenerator is to store heat during the periods of excessive exhaust. If no heat-storage device were interposed between a mill or hoisting engine and the low-pressure turbine, the pressure in the exhaust would vary to such an extent that the relief valve, controlling the maximum pressure in the pipe between the engine and the turbine, would blow off the greater part of the steam, and the economy resulting from the use of exhaust steam would be very slight. If the turbine is to run on live steam only occasionally, the boilers can furnish steam to the low-pressure turbine through a reducing valve; the loss in such a case, resulting from wire-drawing, is in no wise commercially prohibitive.

Nevertheless, it is always desirable to have a mixed-flow turbine, on account of the possibility of efficiently utilizing boiler steam in the machine and consequently always having at hand a high-pressure spare unit working with good steam consumption. This second consideration is by no means the least, and it is probable that in the near future a great many plants contemplating the use of low-pressure turbines will require that when running on high-pressure steam, the turbine shall be as efficient as possible.

Steam turbines lend themselves readily to the use of steam at different pressures. From the very start, turbines of large capacity were built in two sections: the high-pressure section and the low-pressure section, this construction having been used by Parsons and Rateau. It is also well known that overloads are handled in steam turbines by introducing high-pressure steam in the low-pressure stages of the turbine.

The difficulties which had to be solved in the practical design of mixed-flow turbines were confined to regulating means adapted to allow a proper amount of steam from either source to be admitted to the turbine under all load conditions, and, at the same time, to obtain as close a speed regulation as possible.

The solution of this problem calls for a regulating device allowing the turbine to use all the exhaust steam available and also adapted to allow all deficiency in the low-pressure steam supply to be made up by high-pressure steam.

Before considering the means of regulation of the turbine, it is somewhat interesting to analyze what has been done up to the present time in the design of machines utilizing high- as well as low-pressure steam. Two methods prevail.

The first consists in having a turbine so constructed that the high-pressure

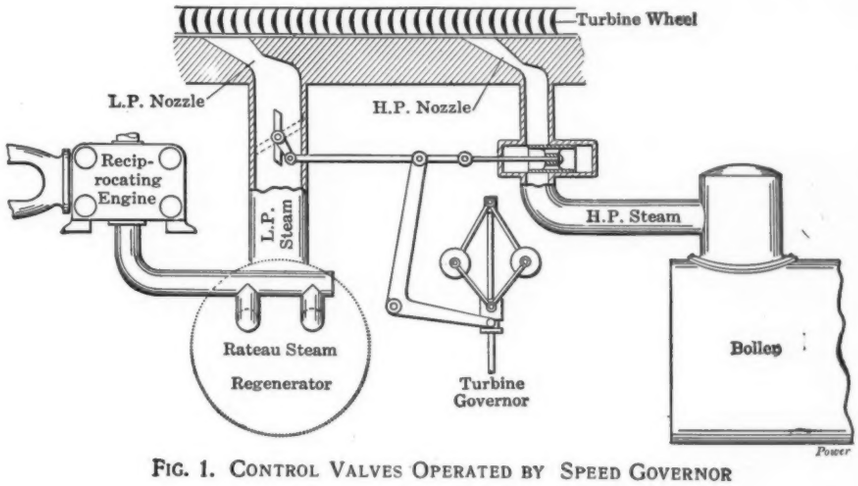


FIG. 1. CONTROL VALVES OPERATED BY SPEED GOVERNOR

steam is admitted automatically through an auxiliary high-pressure section of the turbine. In this case, high-pressure steam goes through high-pressure nozzles and wheels, and after the steam has worked in the high-pressure wheels and has been expanded to practically atmospheric pressure, it enters the low-pressure part of the turbine, in which it expands down to the pressure of the condenser. When low-pressure steam is admitted to the turbine, it enters the low-pressure section of the turbine only. When running as a low-pressure turbine, such an engine will have a set of high-pressure wheels revolving idle in the steam. The loss due to friction in the high-pressure part of the turbine is very small and the efficiency of the turbine is not appreciably altered.

The second method consists in utilizing high- and low-pressure steam on the same turbine wheels, the steam acting on the same buckets in both cases. The low-pressure steam is admitted through one set of nozzles and the high-pressure steam through another set of nozzles. The nozzles are calculated in such a way as to properly expand the steam from either source.

This method avoids the only disadvantage of the first, but has very serious drawbacks of its own. The turbine nozzles have to be designed so as to give a drop in pressure from that of the boiler down to a fraction of atmospheric pressure nozzles from 150 pounds to one-half an atmosphere under full-load conditions.

The first wheel of a machine so designed will develop very inefficiently a large amount of power and the following wheels will be working as if running on fractional loads, and therefore at low efficiency. The efficiency of the machine as a whole will be greatly reduced when using high-pressure steam, and although it can be designed to have a very high efficiency when running on low-pressure steam, it will always have a poor efficiency when running on high-pressure steam.

In order to allow the reciprocating engines compounded with the low-pressure turbine to have a constant pressure at their exhaust, a valve operated by the

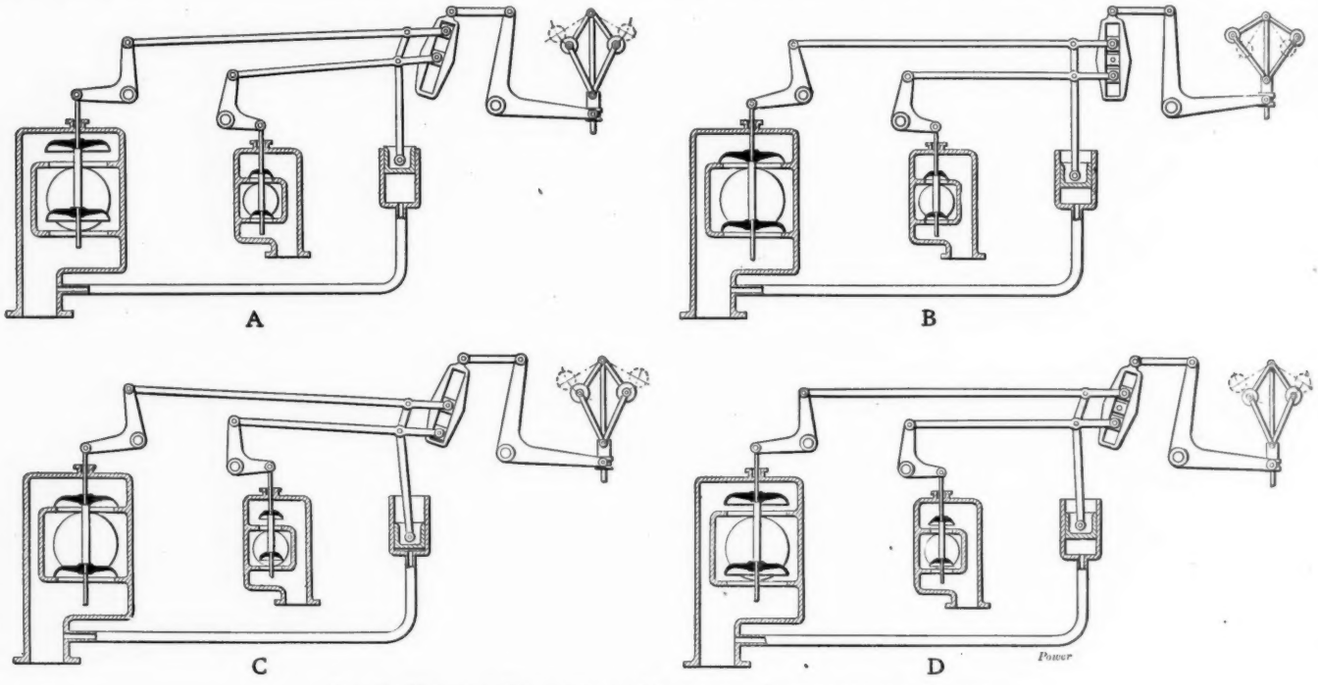


FIG. 2. VARIOUS POSITIONS OF HIGH- AND LOW-PRESSURE VALVES

Machines of this type can be designed to meet all industrial requirements, as the high-pressure part of the turbine can be so designed as to constitute with the low-pressure end a complete high-pressure turbine having, therefore, as high an efficiency when running on high pressure as a straight high-pressure machine. These machines are especially desirable when the mixed-flow turbine is intended to be run frequently on high pressure, or is expected to be run as a high-pressure unit when the reciprocating engine is shut down.

In case the mixed-flow turbine is intended to run only occasionally on high pressure, the high-pressure part of the turbine can be reduced to one or two wheels, and the loss when the turbine is running on straight low pressure will become insignificant.

On the other hand, when running on high and low pressure simultaneously, the turbine will have very good economy and the loss due to the high-pressure wheels turning idle in the steam will be entirely eliminated.

pressure, and the great velocities created through the high-pressure nozzles are utilized in the first turbine wheel. This causes a rapid wear of the buckets and also places the turbine under very bad conditions of steam consumption, on account of the extreme velocity of the steam. A very reliable safety stop must be provided, for if the machine should get beyond control of the governor it would run away and reach a speed so far in excess of normal that the machine would be wrecked.

For example, a mixed-flow turbine of the type described, utilizing steam from sources at respectively 15 pounds and 150 pounds absolute, would have to utilize steam velocities caused by the drop of pressure in the low-pressure nozzles from 15 pounds to approximately one-half the pressure of the atmosphere, and would also have to utilize the velocity of steam expanding through the high-pressure in the exhaust opens when the back pressure on the reciprocating engines reaches 16 pounds absolute and closes when the pressure is lower than 16 pounds. The use of such an auxiliary pressure-actuated valve is imperative, for when the exhaust-steam supply is insufficient to maintain the load on the mixed-flow turbo-alternator, the high-pressure valve must open and admit high-pressure steam to the turbine; creating, through the low-pressure nozzles in the open exhaust line, a depression equal to 58 per cent. of the atmospheric pressure when the turbine is running at full load. This depression can reach as low as the vacuum in the condenser when the load decreases.

If the pressure-actuated valve were not placed between the reciprocating engines and the turbine, the former would run condensing and noncondensing, which would be a highly objectionable

feature. It is also apparent that when the turbine is running on high-pressure steam, the low-pressure pipes from the cylinders of the engines to the turbines would be under vacuum; thence, the glands of the engines, the joints of the piping, etc., would leak air, thus jeopardizing the vacuum in the condenser and increasing the steam consumption of the turbine.

Both high- and low-pressure nozzles in this turbine have to expand steam from an initial pressure of 15 pounds in one case and 150 pounds in the other, down to a fraction of the atmospheric pressure. When the high-pressure valve begins to open, the low-pressure valve is wide open; therefore the pressure in the first turbine-wheel chamber being a fraction of the atmospheric pressure, the depression will be allowed a free channel through the wide-open low-pressure valve, and will reach the reciprocating-engine cylinders.

When the turbine is running on full load, this depression will be approximately one-half atmosphere, and when the turbine is running on fractional loads this depression can become very nearly as great as the vacuum in the condenser. The reciprocating engine will, therefore, be placed under variable exhaust pressures. When the turbine is running on low pressure, the engine will run noncondensing, and when the turbine is running on high-pressure steam, the engine will run condensing.

It is hard to realize how such an equipment will act automatically with reasonable promptness, as the speed of the turbine is controlled by the speed on the entire load on the plant, which is dependent only to a certain extent on the turbine load itself.

Another installation consists of a mixed-flow turbine of a type similar to the one already mentioned, in which the exhaust steam is delivered to the turbine by a reversing engine, utilizing a steam regenerator of very large heat-storage capacity.

The turbine in this case has steam-control valves located in the high-pressure and in the low-pressure steam piping, both valves being operated by the turbine speed governor, as shown in Fig. 1.

The speed governor acts upon the low-pressure valve up to the point where the valve is wide open and then overtravels and starts to operate the high-pressure valve. In other words, when the speed of the turbine begins to drop, the governor admits live steam to the turbine. This gives a poor regulation to the turbine, for if there is a 2 per cent. variation on the low-pressure valve, there will also be 2 per cent. variation on the high-pressure valve, giving ultimately a variation range of 4 per cent.

The machine referred to is direct connected to an alternator running in parallel with other engines.

The synchronous speed on the entire plant affects the turbo-alternator speed and therefore the steam-controlling valves. It is very hard to say why the speed governor should overtravel or why the speed governor should close the high-pressure valve and pick up on the low-pressure supply.

All the considerations mentioned on the first plant also apply to this second plant.

In this equipment, vacuum is allowed to reach the steam regenerator and slowly cool down by evaporating the mass of water contained therein, and after a certain time it reaches the main engine.

It is objectionable to run reversing engines condensing and noncondensing for many reasons.

In the plant referred to it was thought imperative to put a pressure-controlled valve, opening and closing the low-pressure steam supply, to prevent the vacuum from reaching the main engine. This we believe is not a solution of the problem, as in many instances the mixed-flow turbine ought to run on high- and low-pressure steam simultaneously.

The regenerator under these conditions is prevented from storing up heat between as wide limits as could be afforded if the admission of steam to the turbine were not only high or low pressure, but high and low simultaneously. The regenerator will discharge to the atmosphere all the steam as soon as the temperature of the entire mass of liquid equals the corresponding temperature of the maximum steam pressure allowable in the system, in practice generally some three or four pounds gage.

A third installation, recently put in operation at the Milwaukee Coke and Gas Company, Milwaukee, Wis., is equipped with a turbine having supplementary wheels for high pressure and is regulated by means of the mixed-flow governor patented by Professor Rateau several years ago. This regulating apparatus has met with great success abroad.

The device regulates the admission to the turbine from the low-pressure or high-pressure source, independent of the turbine speed. Both valves can be partially opened, but when the pressure in the low-pressure source becomes less than a predetermined amount, the low-pressure valve automatically closes and the low-pressure source is entirely cut off. There is no danger, therefore, that the vacuum in the turbine will reach the main engine.

Sketch *A*, Fig. 2, shows the low-pressure valve open and the high-pressure valve closed; *B* shows both valves closed; *C* shows the high-pressure valve open and the low-pressure valve closed; and *D* shows both valves open. These illustrations are self-explanatory and show the piston control in its several positions.

When the pressure in the low-pressure supply decreases, the piston goes down, acting upon the links connecting the fly balls and the bell cranks controlling the valves. The governor motion is transmitted to the rods through a slotted link in which the rods are held by sliding blocks.

The sketches are intended only to show the motion of the links. In practice the apparatus is built without any slotted link and a similar motion to the one illustrated is obtained through links oscillating on knife edges, the type of link being similar to that employed in the reversing gear of mill engines.

The pressure control does not actuate a piston, but displaces a floating bell, thus preventing all possibility of excessive friction and sticking. This regulating apparatus allows a turbine to run on high- or low-pressure steam or both, and the selection of the source of steam supply is absolutely independent of the speed variation of the turbine.

In view of the preceding remarks, the writer believes that the proper way to design a turbine utilizing steam at different pressures is to use a set of wheels for the expansion of steam from boiler pressure to the pressure of the lower source.

The turbine is safer and more efficient when using high-pressure steam.

The means to regulate a mixed-flow turbine ought to be controlled by the pressure in the low-pressure source, so as to utilize all the low-pressure steam available and to make up deficiencies of low-pressure steam through the use of boiler steam. It is also considered imperative that when the high-pressure valve opens, the governor motion on the links should close the low-pressure valves.

It is interesting to remark that overloads can be obtained in a mixed-flow turbine, this overload being equal to the amount of power developed by the steam when expanding in the high-pressure wheels from boiler pressure to that of the low-pressure steam supply.

This overload is obtained with maximum steam economy, i.e,, the turbine will have its maximum economy when running at the greatest load it can possibly carry on high-pressure steam. This feature is extremely valuable.

Some sixty turbines equipped with this regulating apparatus have been built by European manufacturers of the Rateau turbine and have been in operation for several years, giving excellent results.

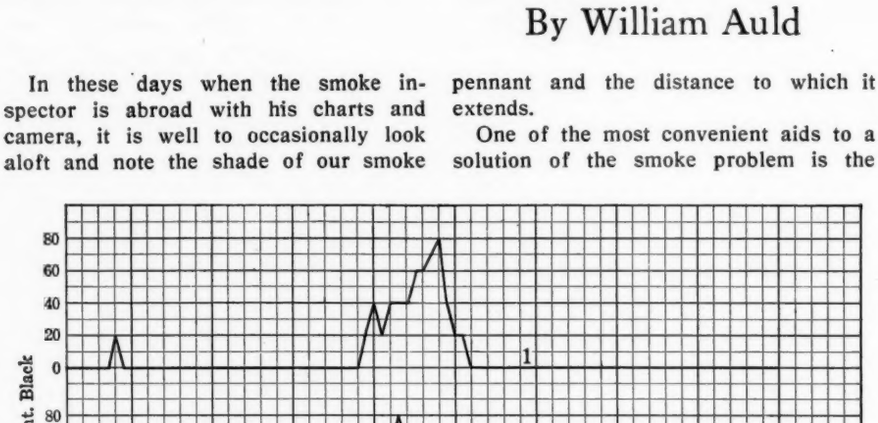
The Rateau-Smoot turbine manufactured by the Ball & Wood Company for the Milwaukee Coke and Gas Company is the first ever built in this country which uses automatically high- and low-pressure steam.

Use of the Ringelman Smoke Scale

By William Auld

In these days when the smoke inspector is abroad with his charts and camera, it is well to occasionally look aloft and note the shade of our smoke pennant and the distance to which it extends.

One of the most convenient aids to a solution of the smoke problem is the "Ringleman Scale for Grading the Density of Smoke," shown herewith. For the benefit of those not already familiar with its use a short description may be in order.



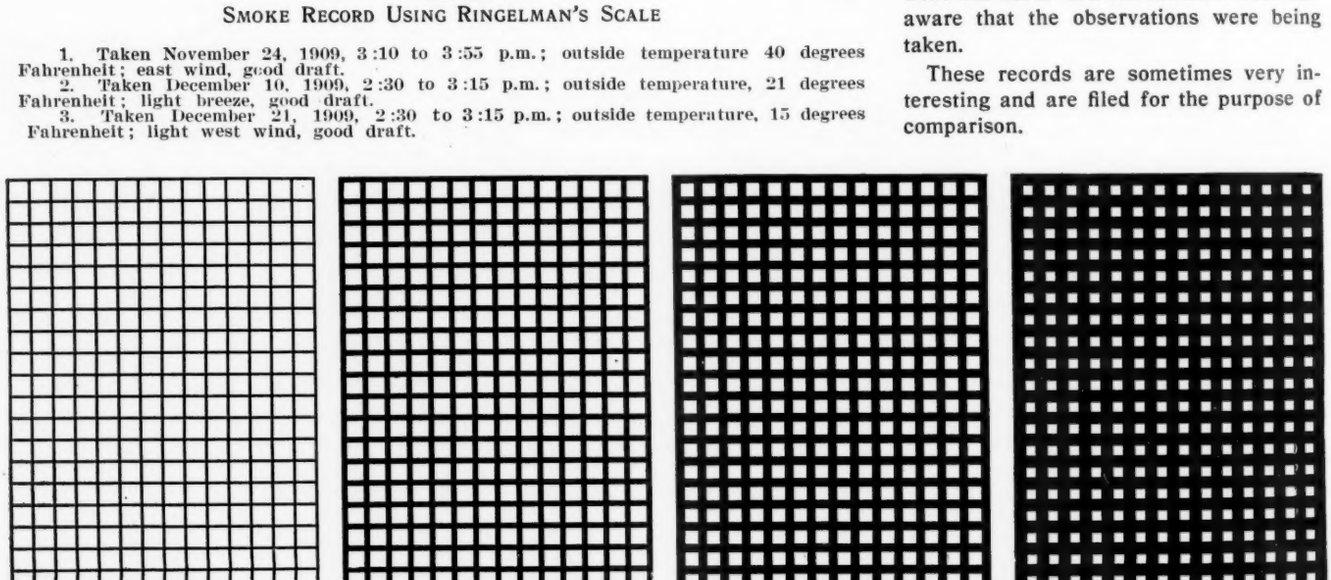
SMOKE RECORD USING RINGELMAN'S SCALE

1. Taken November 24, 1909, 3:10 to 3:55 p.m.; outside temperature 40 degrees Fahrenheit; east wind, good draft.
2. Taken December 10, 1909, 2:30 to 3:15 p.m.; outside temperature, 21 degrees Fahrenheit; light breeze, good draft.
3. Taken December 21, 1909, 2:30 to 3:15 p.m.; outside temperature, 15 degrees Fahrenheit; light west wind, good draft.

The scale, which is considerably reduced in the illustration, should be mounted upon cardboard and located in a quiet spot about 80 to 100 yards from the chimney and as nearly as possible in line with it and the observer, the latter standing about 50 feet from the scale, which should also be on a level with the eye. Then with watch in hand, compare the smoke and the scale and make note of the corresponding density every half minute.

It is a good plan to plot these observations right in the field, using cross-section paper already marked with minutes as abscissas and density as ordinates. A sample chart of this kind, showing the results of observations recently made by the writer, is given on this page. In these three cases the general conditions as to quality of fuel, load, etc. were the same and the firemen were unaware that the observations were being taken.

These records are sometimes very interesting and are filed for the purpose of comparison.



20 per cent. black | 40 per cent. black | 60 per cent. black | 80 per cent. black

RINGELMAN'S SCALE FOR GRADING THE DENSITY OF SMOKE

Casey came into O'Brien's engine room one morning and dropped down into a chair with a sigh that sounded like the exhaust of a Corliss engine when it carries its dashpots with 200 pounds of steam.

"What's th' mather, Casey?" says O'Brien, "Has yer floywhale sphrung a lake, or has yer biler busted?"

"Naythur wan;" says Casey, "th' thrubbel is thot th' Ould Lady thinks thot *her* biler is goin' t' bust. Ye see it's this way: She read an arthicle in th' POWER, by 'Bill' Bangor, 'bout a biler bustin' an' killin' a lot av paypul entoirely. Bill said thot th' rayson it busted was becaws it had no safety valve; an' now she schwares thot she'll niver wash me shirt agin until oi've put a safety valve awn her wash biler. Oi've thried t' argy her out av it, but Oi can't make it go. She says thot awl bilers look aloike t' her, jist th' same as coons; an' Oi reckon thot she'll be afther wantin' me t' put wan awn t' th' tay kittle next. It bates th' divil how much thrubbel we married min do have, annyway."

Equivalent Evaporation f. & a. 212°

By F. R. Low

The tables now in use for reducing boiler performances under various conditions of pressure and temperature to the standard evaporation from and at 212 degrees are based upon the Regnault heat values which have recently been proved to be too low. The accompanying tables, besides being computed with the new and correct values of the Marks-Davis tables, are extended to include feed water above 212 and to include modern high pressures.

It takes more heat to make a pound of steam at a high pressure and temperature out of a pound of cold water than to make a pound of steam at a lower pressure and temperature out of a pound of hot water. In order that boiler performances under different conditions of pressure and feed-water temperature may be comparable it is necessary to reduce them to a common basis, and the accepted basis is feed water of 212 degrees made into steam at atmospheric pressure and 212 degrees.

A table of the physical properties of steam will give the amount of heat required to make a pound of water at 32 degrees into steam at any pressure. It will also give the amount of heat above 32 degrees in a pound of water of any temperature. The difference will be the amount of heat required to make a pound of steam from feed water of any temperature. If this amount of heat is divided by the amount of heat required to evaporate a pound of water from and at 212, the quotient will be the number of pounds which would be evaporated under the standard conditions by the amount of heat required to evaporate a pound under the given conditions. In 1884, William Kent presented to the American Society of Mechanical Engineers a paper entitled "Tables for Facilitating Calculations of Boiler Tests," which included a table of these "Factors of Evaporation," and this table, reproduced in his handbook and other publications, has been much used since. The formula by which it is computed is

$$\frac{H - h}{965.7},$$

H being the total heat in a pound of steam of the observed pressure, h the heat in a pound of the feed water, and 965.7 the number of heat units necessary to evaporate a pound of water from and at 212. The values used were those in Charles T. Porter's "Treatise on the Richards Steam Engine Indicator," published in 1874.

It has been apparent for some time that the total heats of dry saturated steam as determined by Regnault are below the correct values, and a paper presented by Harvey N. Davis, Ph.D., to the Mechanical Engineers in December of 1908 brought this out so positively and established values so evidently more correct that Professor Peabody revised his well known "Steam Tables" to accord therewith and Doctor Davis collaborated with Prof. L. S. Marks, with whom he is associated in the faculty of Harvard University, in the bringing out of a new set of tables with values correct to within one-tenth of one per cent. within the range of pressures ordinarily used.

The value of the heat of evaporation from and at 212 degrees is given in the Davis-Marks tables as 970.4 instead of 965.7. While this does not make a proportionate difference in the factors of evaporation calculated by the above formula, for the values of H change also, it appeared to be worth while to calculate a table with these more correct values and covering a wider range of temperatures and pressures than those referred to. Such a table is presented on pages 850 and 851. Examples of its use are as follows:

A boiler guaranteed to evaporate 11 pounds of water per pound of combustible from and at 212 degrees evaporates 9.23 pounds per pound of combustible from feed water of 50 degrees into steam of 120 pounds gage. Has the guarantee been fulfilled?

In the column headed 135 (for the pressures in the table are absolute like those in the steam tables) and in the horizontal line for 50 degrees find the value 1.2093. This means that every pound of water evaporated from feed water of 50 degrees into steam of 135 pounds absolute requires 1.2093 times as much heat as it does to evaporate one pound from and at 212. The evaporation of 9.23 pounds under the test conditions is equivalent therefore to

$$1.2093 \times 9.23 = 11.16 \text{ pounds}$$

from and at 212. The guarantee is therefore fulfilled.

A boiler running at 90 pounds gage is supplied with feed water of 60 degrees. What would be the saving by heating the feed water to 210 degrees?

Ninety pounds gage is 105 pounds absolute prox*. In the column headed 105 and in the horizontal line for 60 degrees it will be found that it takes 1.1945 times as much heat to make a pound of steam under those conditions as "from and at 212." In the same column the value for 210 degrees is 1.0400. It will therefore take with the hotter feed water

$$1.0400 \div 1.1945 = 0.87$$

of the heat, or results in a saving of

$$100 - 87 = 13 \text{ per cent.}$$

In one plant where the returns are used as boiler feed at an average temperature of 95 degrees and the pressure is 150 pounds gage they make on an average 8.25 pounds of steam with a pound of coal. A neighboring plant carries 100 pounds pressure and uses an economizer which heats the water to 290 degrees. It makes 10 pounds of steam out of the same coal that the first plant uses. Which is doing the better?

The first plant has an equivalent evaporation of

$$1.1665 \times 8.25 = 9.62$$

pounds from and at 212.

The second plant has an equivalent evaporation of

$$0.9579 \times 10 = 9.58$$

pounds from and at 212. The first plant is doing the better.

A boiler is sold under a guarantee to evaporate 10 pounds of water per pound of combustible from feed water of 160 degrees into steam of 120 pounds. During the test the pressure carried averaged 110 pounds and the temperature of the feed water 135 degrees. How many pounds of water must it evaporate per pound of combustible to fulfil the guarantee?

In the column headed 135 pounds and in the line for 160 degrees find that one pound at 135 pounds absolute from feed of 160 degrees is equivalent to 1.0962 pounds from and at 212, and the guaranteed performance of ten pounds under those conditions would be equal to 10.962 pounds from and at 212 degrees.

Under 125 pounds and in the 135-degree line it is seen that one pound under these conditions is equivalent to 1.1206 pounds from and at 212; then 10.962 pounds from and at 212 would be equal to

$$10.962 \div 1.1206 = 9.78$$

pounds from 135 into 110 pounds steam. Since the guaranteed performance of the boiler is equivalent to the first it must also be equivalent to the last, to which that first is equal.

*Absolute pressure is the gage pressure plus the pressure of the atmosphere, which at the sea level is approximately 15 pounds. For high altitudes or where the degree of accuracy required will be affected by so doing the real barometric reading reduced to pounds should be used.

EQUIVALENT EVAPORATION FROM AND AT 212 DEGREES.

COMPUTED WITH THE NEW CORRECTED HEAT VALUES FROM THE MARKS-DAVIS TABLES BY F. R. LOW.

Temperature of Feed Water. Degrees Fahrenheit.	Pressure of Steam in Pounds Absolute—Dry Saturated.												Temperature of Feed Water. Degrees Fahrenheit.
	15	25	35	45	55	65	75	85	95	105	115	125	
32	1.1918	1.1958	1.2024	1.2073	1.2113	1.2144	1.2171	1.2195	1.2216	1.2234	1.2251	1.2266	32
35	1.1887	1.1927	1.1993	1.2042	1.2081	1.2113	1.2140	1.2164	1.2184	1.2203	1.2219	1.2235	35
40	1.1835	1.1875	1.1941	1.1990	1.2030	1.2062	1.2088	1.2112	1.2133	1.2151	1.2168	1.2183	40
45	1.1783	1.1823	1.1889	1.1939	1.1978	1.2010	1.2037	1.2060	1.2081	1.2099	1.2116	1.2131	45
50	1.1732	1.1772	1.1838	1.1887	1.1926	1.1958	1.1985	1.2009	1.2029	1.2048	1.2064	1.2080	50
55	1.1680	1.1720	1.1786	1.1836	1.1875	1.1907	1.1933	1.1957	1.1978	1.1996	1.2013	1.2028	55
60	1.1629	1.1669	1.1735	1.1784	1.1823	1.1855	1.1882	1.1906	1.1926	1.1945	1.1961	1.1977	60
65	1.1577	1.1617	1.1683	1.1733	1.1772	1.1804	1.1830	1.1854	1.1875	1.1893	1.1910	1.1925	65
70	1.1526	1.1566	1.1632	1.1681	1.1720	1.1752	1.1779	1.1803	1.1823	1.1842	1.1858	1.1874	70
75	1.1474	1.1514	1.1580	1.1630	1.1669	1.1701	1.1728	1.1751	1.1772	1.1790	1.1807	1.1823	75
80	1.1423	1.1463	1.1529	1.1578	1.1618	1.1650	1.1676	1.1700	1.1721	1.1739	1.1756	1.1771	80
85	1.1372	1.1412	1.1478	1.1527	1.1566	1.1598	1.1625	1.1649	1.1669	1.1688	1.1704	1.1720	85
90	1.1320	1.1360	1.1426	1.1476	1.1515	1.1547	1.1574	1.1597	1.1618	1.1636	1.1653	1.1668	90
95	1.1269	1.1309	1.1375	1.1424	1.1463	1.1495	1.1522	1.1546	1.1566	1.1585	1.1602	1.1617	95
100	1.1218	1.1258	1.1323	1.1373	1.1412	1.1444	1.1471	1.1495	1.1515	1.1534	1.1550	1.1566	100
105	1.1166	1.1206	1.1272	1.1322	1.1361	1.1393	1.1420	1.1443	1.1464	1.1482	1.1499	1.1516	105
110	1.1115	1.1155	1.1221	1.1270	1.1309	1.1341	1.1368	1.1392	1.1412	1.1824	1.1447	1.1463	110
115	1.1064	1.1103	1.1169	1.1219	1.1258	1.1290	1.1248	1.1341	1.1361	1.1380	1.1396	1.1412	115
120	1.1012	1.1052	1.1118	1.1167	1.1207	1.1239	1.1265	1.1289	1.1310	1.1328	1.1345	1.1360	120
125	1.0961	1.1001	1.1067	1.1116	1.1155	1.1187	1.1214	1.1238	1.1258	1.1277	1.1293	1.1309	125
130	1.0909	1.0949	1.1015	1.1065	1.1104	1.1136	1.1163	1.1186	1.1207	1.1225	1.1242	1.1257	130
135	1.0858	1.0898	1.0964	1.1013	1.1052	1.1084	1.1111	1.1135	1.1155	1.1174	1.1190	1.1206	135
140	1.0806	1.0846	1.0912	1.0962	1.1001	1.1033	1.1060	1.1083	1.1104	1.1123	1.1139	1.1154	140
145	1.0755	1.0795	1.0861	1.0910	1.0950	1.0981	1.1008	1.1032	1.1053	1.1071	1.1088	1.1103	145
150	1.0703	1.0743	1.0809	1.0859	1.0898	1.0930	1.0957	1.0981	1.1001	1.1020	1.1036	1.1052	150
155	1.0652	1.0692	1.0758	1.0807	1.0846	1.0878	1.0905	1.0929	1.0950	1.0968	1.0985	1.1000	155
160	1.0600	1.0640	1.0706	1.0756	1.0795	1.0827	1.0854	1.0877	1.0898	1.0917	1.0933	1.0948	160
165	1.0549	1.0589	1.0655	1.0704	1.0743	1.0775	1.0802	1.0826	1.0846	1.0865	1.0881	1.0897	165
170	1.0497	1.0537	1.0603	1.0653	1.0692	1.0724	1.0751	1.0774	1.0795	1.0813	1.0830	1.0845	170
171	1.0427	1.0527	1.0593	1.0642	1.0681	1.0713	1.0740	1.0764	1.0785	1.0803	1.0820	1.0835	171
172	1.0417	1.0517	1.0583	1.0632	1.0671	1.0703	1.0730	1.0754	1.0774	1.0793	1.0809	1.0825	172
173	1.1406	1.0506	1.0572	1.0622	1.0661	1.0693	1.0720	1.0743	1.0764	1.0782	1.0799	1.0814	173
174	1.0396	1.0496	1.0562	1.0611	1.0651	1.0683	1.0709	1.0733	1.0754	1.0772	1.0789	1.0804	174
175	1.0386	1.0486	1.0552	1.0601	1.0640	1.0672	1.0699	1.0723	1.0743	1.0762	1.0778	1.0793	175
176	1.0375	1.0475	1.0541	1.0591	1.0630	1.0662	1.0689	1.0712	1.0733	1.0752	1.0768	1.0783	176
177	1.0365	1.0465	1.0531	1.0580	1.0620	1.0651	1.0678	1.0702	1.0723	1.0741	1.0758	1.0773	177
178	1.0355	1.0455	1.0521	1.0570	1.0609	1.0641	1.0668	1.0692	1.0712	1.0731	1.0747	1.0763	178
179	1.0344	1.0444	1.0510	1.0560	1.0599	1.0631	1.0658	1.0681	1.0702	1.0721	1.0734	1.0752	179
180	1.0334	1.0434	1.0500	1.0549	1.0589	1.0621	1.0647	1.0671	1.0692	1.0710	1.0727	1.0742	180
181	1.0324	1.0424	1.0490	1.0539	1.0578	1.0610	1.0637	1.0661	1.0681	1.0700	1.0716	1.0732	181
182	1.0313	1.0413	1.0479	1.0529	1.0568	1.0600	1.0627	1.0650	1.0671	1.0690	1.0706	1.0721	182
183	1.0303	1.0403	1.0469	1.0518	1.0558	1.0590	1.0616	1.0640	1.0661	1.0679	1.0696	1.0711	183
184	1.0293	1.0393	1.0459	1.0508	1.0547	1.0579	1.0606	1.0630	1.0650	1.0669	1.0685	1.0701	184
185	1.0282	1.0382	1.0448	1.0498	1.0537	1.0569	1.0596	1.0619	1.0640	0.0659	1.0675	1.0691	185
186	1.0272	1.0372	1.0438	1.0488	1.0527	1.0559	1.0585	1.0609	1.0630	1.0648	1.0665	1.0680	186
187	1.0262	1.0362	1.0428	1.0477	1.0516	1.0548	1.0575	1.0599	1.0619	1.0638	1.0654	1.0670	187
188	1.0251	1.0351	1.0417	1.0467	1.0506	1.0538	1.0565	1.0588	1.0609	1.0628	1.0644	1.0660	188
189	1.0241	1.0341	1.0407	1.0457	1.0496	1.0528	1.0554	1.0578	1.0599	1.0617	1.0634	1.0649	189
190	1.0231	1.0331	1.0397	1.0446	1.0485	1.0517	1.0544	1.0568	1.0588	1.0607	1.0623	1.0639	190
191	1.0220	1.0320	1.0386	1.0436	1.0475	1.0507	1.0534	1.0557	1.0578	1.0597	1.0613	1.0629	191
192	1.0210	1.0310	1.0376	1.0425	1.0465	1.0497	1.0523	1.0547	1.0568	1.0586	1.0603	1.0618	192
193	1.0200	1.0300	1.0366	1.0415	1.0454	1.0486	1.0513	1.0537	1.0557	1.0576	1.0592	1.0608	193
194	1.0189	1.0289	1.0355	1.0405	1.0444	1.0476	1.0503	1.0526	1.0547	1.0566	1.0582	1.0597	194
195	1.0179	1.0279	1.0345	1.0394	1.0434	1.0466	1.0492	1.0516	1.0537	1.0555	1.0572	1.0587	195
196	1.0169	1.0269	1.0335	1.0384	1.0423	1.0455	1.0482	1.0506	1.0526	1.0545	1.0561	1.0577	196
197	1.0158	1.0258	1.0324	1.0374	1.0413	1.0445	1.0472	1.0495	1.0516	1.0535	1.0551	1.0566	197
198	1.0148	1.0248	1.0314	1.0363	1.0403	1.0435	1.0461	1.0485	1.0506	1.0524	1.0541	1.0556	198
199	1.0138	1.0238	1.0304	1.0353	1.0392	1.0424	1.0451	1.0475	1.0495	1.0514	1.0530	1.0546	199
200	1.0127	1.0227	1.0293	1.0343	1.0382	1.0414	1.0441	1.0464	1.0485	1.0504	1.0520	1.0535	200
201	1.0117	1.0217	1.0283	1.0332	1.0372	1.0404	1.0430	1.0454	1.0475	1.0493	1.0510	1.0525	201
202	1.0107	1.0207	1.0273	1.0322	1.0361	1.0393	1.0420	1.0444	1.0464	1.0483	1.0499	1.0515	202
203	1.0096	1.0196	1.0262	1.0312	1.0351	1.0383	1.0410	1.0433	1.0454	1.0472	1.0489	1.0504	203
204	1.0086	1.0186	1.0252	1.0301	1.0340	1.0372	1.0399	1.0423	1.0444	1.0462	1.0479	1.0494	204
205	1.0076	1.0176	1.0242	1.0291	1.0330	1.0362	1.0389	1.0413	1.0433	1.0452	1.0468	1.0484	205
206	1.0065	1.0165	1.0231	1.0281	1.0320	1.0352	1.0379	1.0402	1.0423	1.0441	1.0458	1.0473	206
207	1.0055	1.0155	1.0221	1.0270	1.0309	1.0341	1.0368	1.0392	1.0413	1.0431	1.0448	1.0463	207
208	1.0045	1.0144	1.0210	1.0260	1.0299	1.0331	1.0358	1.0381	1.0402	1.0421	1.0437	1.0453	208
209	1.0034	1.0134	1.0200	1.0250	1.0289	1.0321	1.0347	1.0371	1.0392	1.0410	1.0427	1.0442	209
210	1.0024	1.0124	1.0190	1.0239	1.0278	1.0310	1.0337	1.0361	1.0381	1.0400	1.0416	1.0432	210
212	1.0003	1.0103	1.0169	1.0218	1.0258	1.0290	1.0316	1.0340	1.0361	1.0379	1.0396	1.0411	212
215	0.9972	1.0072	1.0138	1.0188	1.0227	1.0259	1.0285	1.0309	1.0330	1.0348	1.0365	1.0380	215
220	0.9920	1.0020	1.0086	1.0135	1.0174	1.0206	1.0233	1.0257	1.0277	1.0296	1.0312	1.0328	220
225	0.9868	0.9968	1.0034	1.0083	1.0123	1.0155	1.0181	1.0205	1.0226	1.0244	1.0261	1.0276	225
230	0.9816	0.9916	0.9981	1.0031	1.0070	1.0102	1.0129	1.0153	1.0173	1.0192	1.0208	1.0224	230
235	0.9764	0.9864	0.9930	0.9979	1.0019	1.0050	1.0077	1.0101	1.0122	1.0140	1.0157	1.0172	235
240	0.9711	0.9811	0.9877	0.9927	0.9966	0.9998	1.0025	1.0048	1.0069	1.0088	1.0104	1.0120	240
245	0.9660	0.9759	0.9825	0.9874	0.9913	0.9945	0.9972	0.9996	1.0016	1.0035	1.0052	1.0067	245
250	0.9606	0.9706	0.9772	0.9822	0.9861	0.9893	0.9920	0.9943	0.9964	0.9982	0.9999	1.0014	250
255	0.9555	0.9655	0.9721	0.9770	0.9809	0.9841	0.9868	0.9892	0.9912	0.9931	0.9947	0.9963	255
260	0.9502	0.9602	0.9668	0.9718	0.9757	0.9789	0.9816	0.9839	0.9860	0.9878	0.9895	0.9910	260
265	0.9450	0.9550	0.9616	0.9665	0.9704	0.9736	0.9763	0.9787	0.9807	0.9826	0.9842	0.9858	265
270	0.9397	0.9497	0.9563	0.9613	0.9652	0.9684	0.9710	0.9734	0.9755	0.9773	0.9790	0.9805	270
275	0.9345	0.9446	0.9511	0.9560	0.9599	0.9631	0.9658	0.9682	0.9702	0.9721	0.9737	0.9754	275
280	0.9292	0.9392	0.9458	0.9507	0.9547	0.9579	0.9605	0.9629	0.9650	0.9668	0.9685	0.9700	280
285	0.9238	0.9338	0.9404	0.9454	0.9493	0.9525	0.9552	0.9575	0.9596	0.9615	0.9631	0.9647	285
290	0.9186	0.9286	0.9352	0.9401	0.9440	0.9472	0.9499	0.9523	0.9543	0.9562	0.9579	0.9594	290
295	0.9133	0.9233	0.9299	0.9349	0.9388	0.9420	0.9447	0.9470	0.9491	0.9509	0.9526	0.9541	295
300	0.9080	0.9180	0.9246	0.9295	0.9334	0.9366	0.9393	0.9417	0.9437	0.9456	0.9472	0.9488	300

EQUIVALENT EVAPORATION FROM AND AT 212 DEGREES.

COMPUTED WITH THE NEW CORRECTED HEAT VALUES FROM THE MARKS-DAVIS TABLES BY F. R. LOW.

Temperature of Feed Water. Degrees Fahrenheit.	Pressure of Steam in Pounds Absolute—Dry Saturated.												Temperature of Feed Water. Degrees Fahrenheit.
	135	145	155	165	175	185	195	205	215	225	235	245	
32	1.2279	1.2292	1.2304	1.2315	1.2324	1.2333	1.2342	1.2351	1.2357	1.2365	1.2372	1.2378	32
35	1.2248	1.2261	1.2273	1.2283	1.2293	1.2302	1.2311	1.2319	1.2326	1.2334	1.2341	1.2347	35
40	1.2197	1.2209	1.2221	1.2232	1.2241	1.2250	1.2259	1.2268	1.2274	1.2282	1.2289	1.2295	40
45	1.2145	1.2157	1.2170	1.2180	1.2189	1.2198	1.2208	1.2216	1.2222	1.2230	1.2238	1.2244	45
50	1.2093	1.2106	1.2118	1.2128	1.2137	1.2147	1.2156	1.2164	1.2170	1.2179	1.2186	1.2192	50
55	1.2042	1.2054	1.2066	1.2077	1.2086	1.2095	1.2104	1.2113	1.2119	1.2127	1.2134	1.2141	55
60	1.1990	1.2002	1.2015	1.2025	1.2034	1.2044	1.2053	1.2061	1.2067	1.2076	1.2083	1.2089	60
65	1.1939	1.1951	1.1963	1.1974	1.1983	1.1992	1.2002	1.2010	1.2016	1.2024	1.2031	1.2038	65
70	1.1887	1.1900	1.1912	1.1922	1.1932	1.1941	1.1950	1.1958	1.1965	1.1973	1.1980	1.1986	70
75	1.1836	1.1848	1.1861	1.1871	1.1880	1.1889	1.1899	1.1907	1.1913	1.1921	1.1929	1.1935	75
80	1.1785	1.1797	1.1809	1.1820	1.1829	1.1838	1.1847	1.1856	1.1862	1.1870	1.1877	1.1883	80
85	1.1733	1.1745	1.1758	1.1768	1.1777	1.1787	1.1796	1.1804	1.1810	1.1819	1.1826	1.1832	85
90	1.1682	1.1694	1.1707	1.1717	1.1726	1.1735	1.1745	1.1753	1.1759	1.1767	1.1775	1.1781	90
95	1.1630	1.1643	1.1655	1.1665	1.1675	1.1684	1.1693	1.1701	1.1708	1.1716	1.1723	1.1729	95
100	1.1579	1.1591	1.1604	1.1614	1.1623	1.1633	1.1642	1.1650	1.1657	1.1665	1.1672	1.1678	100
105	1.1528	1.1540	1.1552	1.1563	1.1572	1.1581	1.1591	1.1599	1.1606	1.1613	1.1620	1.1627	105
110	1.1476	1.1489	1.1501	1.1511	1.1521	1.1530	1.1539	1.1547	1.1555	1.1562	1.1569	1.1575	110
115	1.1425	1.1437	1.1450	1.1460	1.1469	1.1479	1.1488	1.1496	1.1503	1.1511	1.1518	1.1524	115
120	1.1374	1.1386	1.1398	1.1409	1.1418	1.1427	1.1436	1.1445	1.1452	1.1459	1.1466	1.1472	120
125	1.1322	1.1335	1.1347	1.1357	1.1366	1.1376	1.1385	1.1393	1.1400	1.1408	1.1415	1.1421	125
130	1.1271	1.1283	1.1295	1.1306	1.1315	1.1324	1.1334	1.1342	1.1349	1.1356	1.1363	1.1370	130
135	1.1219	1.1232	1.1244	1.1254	1.1264	1.1273	1.1282	1.1290	1.1298	1.1305	1.1312	1.1318	135
140	1.1168	1.1180	1.1193	1.1203	1.1212	1.1221	1.1231	1.1239	1.1246	1.1253	1.1261	1.1267	140
145	1.1116	1.1129	1.1141	1.1151	1.1161	1.1170	1.1179	1.1188	1.1195	1.1202	1.1209	1.1215	145
150	1.1065	1.1077	1.1090	1.1100	1.1109	1.1119	1.1128	1.1136	1.1143	1.1150	1.1158	1.1164	150
155	1.1013	1.1026	1.1038	1.1048	1.1058	1.1067	1.1076	1.1085	1.1092	1.1099	1.1106	1.1112	155
160	1.0962	1.0974	1.0987	1.0997	1.1006	1.1015	1.1025	1.1033	1.1040	1.1047	1.1055	1.1061	160
165	1.0910	1.0923	1.0935	1.0945	1.0955	1.0964	1.0973	1.0981	1.0989	1.0996	1.1003	1.1009	165
170	1.0859	1.0871	1.0883	1.0894	1.0903	1.0912	1.0922	1.0930	1.0937	1.0944	1.0951	1.0958	170
171	1.0848	1.0861	1.0873	1.0883	1.0893	1.0902	1.0911	1.0920	1.0927	1.0934	1.0941	1.0947	171
172	1.0838	1.0850	1.0863	1.0873	1.0882	1.0892	1.0901	1.0909	1.0916	1.0924	1.0931	1.0937	172
173	1.0828	1.0840	1.0853	1.0863	1.0872	1.0881	1.0891	1.0899	1.0906	1.0913	1.0921	1.0927	173
174	1.0817	1.0830	1.0842	1.0853	1.0862	1.0871	1.0880	1.0889	1.0896	1.0903	1.0910	1.0916	174
175	1.0807	1.0820	1.0832	1.0842	1.0852	1.0861	1.0870	1.0878	1.0886	1.0893	1.0900	1.0906	175
176	1.0797	1.0809	1.0822	1.0832	1.0841	1.0850	1.0860	1.0868	1.0875	1.0882	1.0890	1.0896	176
177	1.0786	1.0799	1.0811	1.0822	1.0831	1.0840	1.0849	1.0858	1.0865	1.0872	1.0879	1.0885	177
178	1.0776	1.0789	1.0801	1.0811	1.0820	1.0830	1.0839	1.0847	1.0854	1.0862	1.0869	1.0875	178
179	1.0766	1.0778	1.0791	1.0801	1.0810	1.0819	1.0829	1.0837	1.0844	1.0851	1.0859	1.0865	179
180	1.0756	1.0768	1.0780	1.0791	1.0800	1.0809	1.0818	1.0827	1.0834	1.0841	1.0848	1.0854	180
181	1.0745	1.0758	1.0770	1.0780	1.0790	1.0799	1.0808	1.0816	1.0824	1.0831	1.0838	1.0844	181
182	1.0735	1.0747	1.0760	1.0770	1.0779	1.0788	1.0798	1.0806	1.0813	1.0820	1.0828	1.0834	182
183	1.0725	1.0737	1.0749	1.0760	1.0769	1.0778	1.0787	1.0796	1.0803	1.0810	1.0817	1.0823	183
184	1.0714	1.0727	1.0739	1.0749	1.0759	1.0768	1.0777	1.0785	1.0793	1.0800	1.0807	1.0813	184
185	1.0704	1.0716	1.0729	1.0739	1.0748	1.0758	1.0767	1.0775	1.0782	1.0789	1.0797	1.0803	185
186	1.0694	1.0706	1.0718	1.0729	1.0738	1.0747	1.0756	1.0765	1.0772	1.0779	1.0786	1.0793	186
187	1.0683	1.0696	1.0708	1.0718	1.0728	1.0737	1.0746	1.0754	1.0762	1.0769	1.0776	1.0782	187
188	1.0673	1.0685	1.0698	1.0708	1.0717	1.0727	1.0736	1.0744	1.0751	1.0758	1.0766	1.0772	188
189	1.0663	1.0675	1.0687	1.0698	1.0707	1.0716	1.0725	1.0734	1.0741	1.0748	1.0755	1.0762	189
190	1.0652	1.0665	1.0677	1.0687	1.0697	1.0706	1.0715	1.0723	1.0731	1.0738	1.0745	1.0751	190
191	1.0642	1.0654	1.0667	1.0677	1.0686	1.0695	1.0705	1.0713	1.0720	1.0727	1.0735	1.0741	191
192	1.0632	1.0644	1.0656	1.0667	1.0676	1.0685	1.0694	1.0703	1.0710	1.0717	1.0724	1.0731	192
193	1.0621	1.0634	1.0646	1.0656	1.0666	1.0675	1.0684	1.0692	1.0700	1.0707	1.0714	1.0720	193
194	1.0611	1.0623	1.0636	1.0646	1.0655	1.0664	1.0674	1.0682	1.0689	1.0696	1.0704	1.0710	194
195	1.0601	1.0613	1.0625	1.0636	1.0645	1.0654	1.0663	1.0672	1.0679	1.0686	1.0693	1.0700	195
196	1.0590	1.0603	1.0615	1.0625	1.0635	1.0644	1.0653	1.0661	1.0669	1.0676	1.0683	1.0689	196
197	1.0580	1.0592	1.0605	1.0615	1.0624	1.0633	1.0643	1.0651	1.0658	1.0665	1.0673	1.0679	197
198	1.0570	1.0582	1.0594	1.0605	1.0614	1.0623	1.0632	1.0641	1.0648	1.0655	1.0662	1.0668	198
199	1.0559	1.0572	1.0584	1.0594	1.0603	1.0613	1.0622	1.0630	1.0637	1.0645	1.0652	1.0658	199
200	1.0549	1.0561	1.0574	1.0584	1.0593	1.0602	1.0612	1.0620	1.0627	1.0634	1.0642	1.0648	200
201	1.0539	1.0551	1.0563	1.0574	1.0584	1.0592	1.0601	1.0610	1.0617	1.0624	1.0631	1.0637	201
202	1.0528	1.0541	1.0553	1.0563	1.0572	1.0582	1.0591	1.0599	1.0606	1.0614	1.0621	1.0627	202
203	1.0518	1.0530	1.0543	1.0553	1.0562	1.0571	1.0581	1.0589	1.0596	1.0603	1.0611	1.0617	203
204	1.0507	1.0520	1.0532	1.0542	1.0552	1.0561	1.0570	1.0579	1.0586	1.0593	1.0600	1.0606	204
205	1.0497	1.0509	1.0522	1.0532	1.0541	1.0551	1.0560	1.0568	1.0575	1.0583	1.0590	1.0596	205
206	1.0487	1.0499	1.0511	1.0522	1.0531	1.0540	1.0550	1.0558	1.0565	1.0572	1.0579	1.0586	206
207	1.0476	1.0489	1.0501	1.0511	1.0521	1.0530	1.0539	1.0548	1.0555	1.0562	1.0569	1.0575	207
208	1.0466	1.0478	1.0491	1.0501	1.0510	1.0520	1.0529	1.0537	1.0544	1.0552	1.0559	1.0565	208
209	1.0456	1.0468	1.0480	1.0491	1.0500	1.0509	1.0519	1.0527	1.0534	1.0541	1.0548	1.0555	209
210	1.0445	1.0458	1.0470	1.0480	1.0490	1.0499	1.0508	1.0516	1.0524	1.0531	1.0538	1.0544	210
212	1.0425	1.0437	1.0449	1.0460	1.0469	1.0478	1.0487	1.0496	1.0503	1.0510	1.0517	1.0523	212
215	1.0394	1.0406	1.0418	1.0429	1.0438	1.0447	1.0457	1.0465	1.0472	1.0479	1.0486	1.0493	215
220	1.0341	1.0353	1.0366	1.0376	1.0385	1.0395	1.0404	1.0412	1.0419	1.0427	1.0434	1.0440	220
225	1.0290	1.0302	1.0314	1.0325	1.0334	1.0343	1.0352	1.0361	1.0368	1.0375	1.0382	1.0388	225
230	1.0237	1.0249	1.0262	1.0272	1.0281	1.0291	1.0300	1.0308	1.0315	1.0323	1.0330	1.0336	230
235	1.0185	1.0198	1.0210	1.0221	1.0230	1.0239	1.0248	1.0257	1.0264	1.0271	1.0278	1.0284	235
240	1.0133	1.0145	1.0158	1.0168	1.0177	1.0187	1.0196	1.0204	1.0211	1.0218	1.0226	1.0232	240
245	1.0080	1.0093	1.0105	1.0115	1.0125	1.0134	1.0143	1.0151	1.0159	1.0166	1.0173	1.0179	245
250	1.0028	1.0040	1.0053	1.0063	1.0072	1.0081	1.0091	1.0099	1.0166	1.0113	1.0121	1.0127	250
255	0.9976	0.9989	1.0001	1.0011	1.0021	1.0030	1.0039	1.0047	1.0055	1.0062	1.0069	1.0075	255
260	0.9924	0.9936	0.9948	0.9959	0.9968	0.9977	0.9987	0.9995	1.0002	1.0009	1.0016	1.0023	260
265	0.9871	0.9884	0.9896	0.9906	0.9915	0.9925	0.9934	0.9942	0.9950	0.9957	0.9964	0.9970	265
270	0.9819	0.9831	0.9843	0.9854	0.9863	0.9872	0.9881	0.9890	0.9897	0.9904	0.9911	0.9918	270
275	0.9766	0.9778	0.9791	0.9801	0.9810	0.9820	0.9829	0.9837	0.9844	0.9852	0.9859	0.9865	275
280	0.9714	0.9726	0.9738	0.9749	0.9758	0.9767	0.9776	0.9785	0.9792	0.9799	0.9806	0.9812	280
285	0.9660	0.9672	0.9685	0.9695	0.9704	0.9714	0.9723	0.9731	0.9738	0.9745	0.9753	0.9759	285
290	0.9607	0.9620	0.9632	0.9642	0.9652	0.9661	0.9670	0.9678	0.9686	0.9693	0.9700	0.9706	290
295	0.9555	0.9567	0.9580	0.9590	0.9599	0.9608	0.9618	0.9626	0.9633	0.9640	0.9648	0.9654	295
300	0.9501	0.9514	0.9526	0.9536	0.9546	0.9555	0.9564	0.9572	0.9580	0.9587	0.9594	0.9600	300

Electrical Department

Three-wire Alternating Current Circuits

By Cecil P. Poole

Especially conducted to be of interest and service to the men in charge of the electrical equipment.

When anyone says "three-wire circuit," referring to direct-current work, everyone knows that he means the familiar arrangement of three wires and two voltages, the voltage between the middle wire and each outside wire being one-half the voltage between the two outside wires direct. But if alternating-current work is being discussed, it is impossible to tell just what is meant by the expression "three-wire circuit" unless more information is given as to what the circuit is. There is the single-phase three-wire circuit, which is exactly the same in principle as the old three-wire direct-current circuit; the two-phase three-wire circuit, which is a little similar but not entirely the same, and the three-phase three-wire circuit, which is totally different in all respects excepting the number of wires.

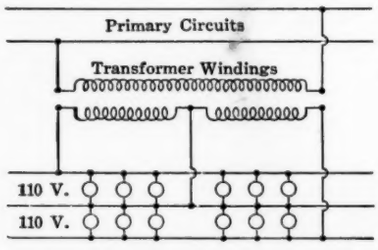


Fig. 1. Three-wire Supply from One Transformer

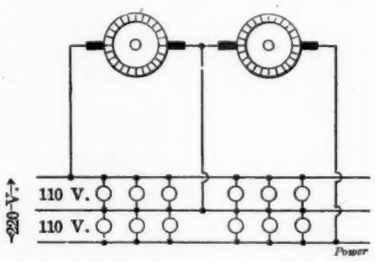


Fig. 2 Direct-current Three-wire System

Single-phase Three-wire Circuits

Single-phase three-wire circuits are always secondary circuits, because there is no advantage in making a single-phase primary circuit three-wire. The most common method of supplying a three-wire circuit is by connecting the secondary windings of a transformer in series and bringing out a neutral connection from the junction of the windings, exactly as is done in the direct-current system using two dynamos (see Fig. 2); the secondary windings of the transformer correspond precisely to the armatures of the two direct-current dynamos, as Figs. 1 and 2 indicate, but the transformer arrangement has not the great advantage of individual voltage regulation which the two dynamos have. With a circuit supplied as described, the load on opposite sides of the neutral should be kept very nearly balanced in order to avoid having lamps on the heavily loaded side of the circuit burn much more dimly than those on the other side, due to the difference in voltage drop.

The difference of potential, or "voltage," between the two outside wires of the circuit is twice that between the middle wire and each outside wire, exactly as in the direct-current system, so long as the loads in the two divisions of the circuit are equal or practically equal. The advantage of double voltage, which is the strong point of the direct-current system, is also obtained with the corresponding arrangement of transformer secondary windings. If each section of the secondary winding gives 110 volts, which is the usual arrangement, connecting the two sections up for three-wire distribution, as in Fig. 1, gives 220 volts between the main wires, permitting the use of one-fourth the weight of copper in those wires that would be required in a 110-volt circuit having the same load and loss.

Sometimes it is desired to use three-wire distribution from a secondary circuit in order to get a lower voltage instead of a higher one; for example, if it were desired to operate 50-volt tungsten or other high-efficiency lamps from a 100-volt circuit, a three-wire circuit with 50 volts between the neutral and each main wire would just fit the case. Under such conditions, a simple autotransformer might be preferable to an ordinary transformer, especially if a special winding were required on the ordinary transformer to get the required voltages. The winding of the autotransformer would then be connected as indicated in Fig. 3; that is, the terminals would be connected to the main wires of the three-wire circuit and the neutral wire would be connected to the middle point of the winding. The main wires of the three-wire circuit would also be connected to the single-phase two-wire circuit which it is desired to "split." This arrangement has the same disadvantage that the one first described has, that the voltages of the two divisions of the three-wire circuit cannot be regulated, and the loads, therefore, should be kept very nearly balanced. However, it is possible to provide for this feature by leading out several taps from the middle portion of the winding and connecting the neutral wire to any one of these by means of a dial switch, as indicated in the diagram, Fig. 4. As this diagram is drawn, moving the switch handle to the right will increase the voltage between the neutral and the left-hand main wire and decrease it on the other side of the neutral, and *vice versa*. This arrangement is seldom justified in practice, however, because in almost all cases where it is advisable to "split" the regular voltage of a secondary circuit the load is small and of a kind that is easy to balance between the two sides of the three-wire circuit.

When it is desired to supply a three-wire circuit from a single-phase two-wire primary line at twice the usual secondary voltage, two transformers may be connected up with their secondary windings in series, exactly like the two secondary sections in Fig. 1. This connection, which is shown in Fig. 5, gives a voltage between the neutral and each main wire

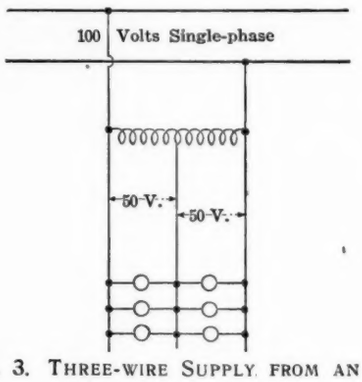


Fig. 3. Three-wire Supply from an Autotransformer

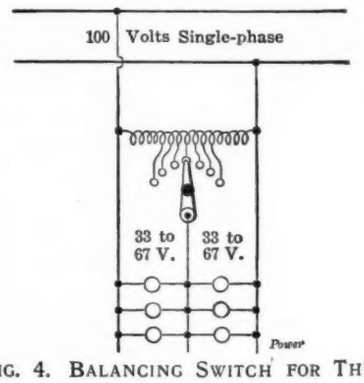


Fig. 4. Balancing Switch for Three-wire Autotransformer

which is twice the voltage that can be obtained with the single-transformer arrangement of Fig. 1. There are few circumstances under which it would be necessary, however. The more usual arrangement of two transformers is that shown in Fig. 6, where the two sections of each secondary winding are connected in parallel and the two complete windings are in series across the main wires

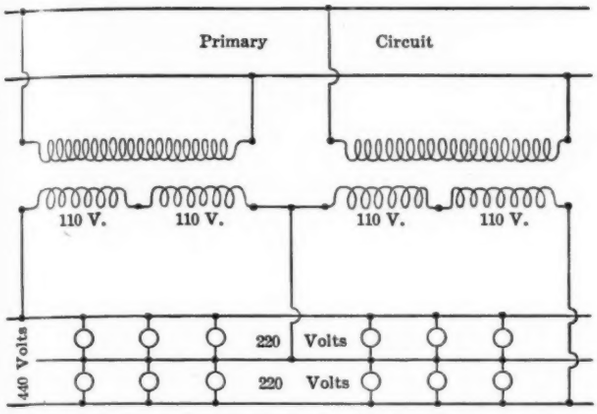


FIG. 5. THREE-WIRE SUPPLY FROM TWO TRANSFORMERS AT MAXIMUM VOLTAGE

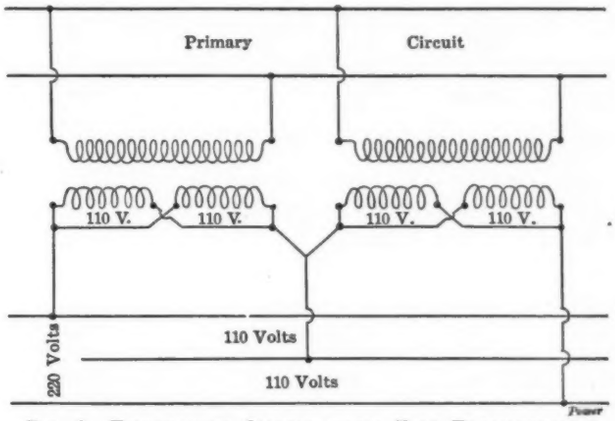


FIG. 6. THREE-WIRE SUPPLY FROM TWO TRANSFORMERS AT USUAL VOLTAGE

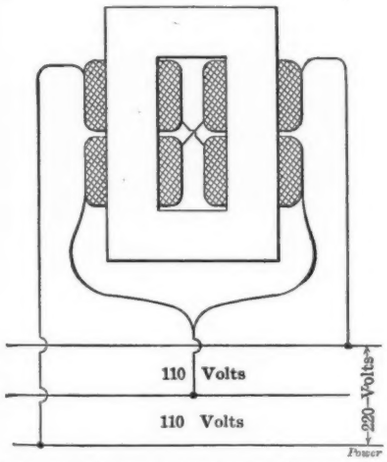


FIG. 7. CROSS-CONNECTED SECONDARY WINDINGS FOR THREE-WIRE SUPPLY

of the three-wire circuit. This gives the advantage of independent magnetic circuits and prevents any objectionable reactions between the secondary windings connected to the two divisions of the circuit. Such reactions are obtained with the single transformer and split secondary represented in Fig. 1 unless the secondary windings of the transformer are divided into four parts, two on each leg, and the parts cross-connected, as shown in Fig. 7, and this is common practice in building transformers which are wanted for three-wire secondary distribution. With the arrangement of Fig. 6, however, no special windings or connections are required.

TWO-PHASE THREE-WIRE CIRCUIT

A two-phase circuit almost invariably consists of four wires, two to each phase, for the reason that the saving in the weight of wire that can be obtained by using three-wire construction does not pay for the disadvantage of using one size of wire for the outer mains and another size for the middle wire, which would be necessary. Fig. 8 is a diagram of an ordinary four-wire two-phase circuit primary, the phases being called "A" and "B" for identification. If the two neighboring wires *b* and *c* of the two phases be consolidated into one wire, the current that will pass in that wire will be practically 41 per cent. greater than the current that each of the original wires *b* and *c* has to carry, if the load is the same. Consequently, the single wire which takes the place of the two wires *b* and *c* needs to have only 1.41 times the cross-section of one of the original wires; that is, the wire *m* in Fig. 9 has a cross-section equal to 71 per cent. of the combined cross-section of the two wires *b* and *c*, Fig. 8. Then the complete three-wire circuit will contain 85 per cent. of the weight of copper that the four-wire circuit would have to have for the same load and line loss; the saving, of course, would be 15 per cent. in line-wire copper. In a three-wire circuit of this kind, the voltage between the outer wires *a* and *d*, Fig. 9, is not twice the voltage between the middle wire and each outer wire; it is only 1.41 times the single voltage. For example, if the e.m.f. between *a* and *m* and between *d* and *m* were 2300 volts, the e.m.f. between *a* and *d* would be

$$2300 \times 1.41 = 3243 \text{ volts,}$$

not 4600.

Three-wire circuits of the kind just described can be operated from generators that have distinct two-phase armature windings, but if the generator has a closed-circuit armature winding, with taps led out for the four circuit wires commonly used, a three-wire circuit cannot be used in place of the four-wire

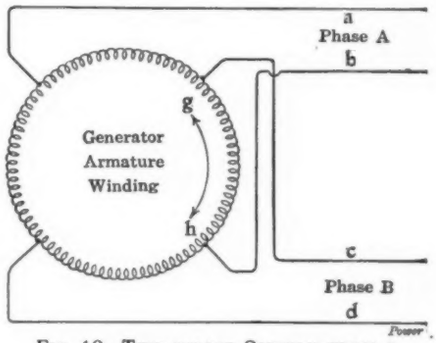


FIG. 10. TWO-PHASE SUPPLY FROM A CLOSED-CIRCUIT ARMATURE WINDING

circuit, because consolidating two of the circuit wires would short-circuit a fourth of the armature winding. This is illustrated diagrammatically in Fig. 10, where the armature winding is represented by the circle of loops, from which four taps lead out to the usual four-wire circuit. It is evident that if the wires *b* and *c* were consolidated into a single wire, as shown in Fig. 9, that part of the armature winding from *g* to *h*, Fig. 10, would be dead short-circuited.

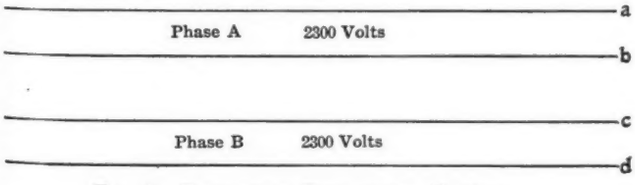


FIG. 8. FOUR-WIRE TWO-PHASE CIRCUIT

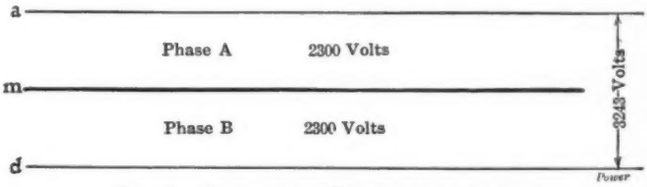


FIG. 9. THREE-WIRE TWO-PHASE CIRCUIT

THREE-PHASE THREE-WIRE CIRCUIT

The standard three-phase circuit is

naturally a three-wire circuit, because it is the equivalent of three single-phase circuits with each wire of each circuit consolidated with a wire of each of the other two circuits. The phase relations of the currents in the circuit make this practical. The three currents do not alternate together but rise and fall one-third of a cycle apart; consequently, when any one of the three currents is at its maximum strength, the other two are at half strength each, so that both of them together are equal to the one that is at its maximum, and their polarity at that instant is exactly opposite to the polarity of the other current. While this exact condition exists only momentarily six times in each complete cycle, the balance between the three currents exists at every instant; that is, the sum of the three is zero, taking into account the instantaneous polarity and strength of each of the three. Therefore, if the three single-phase circuits were connected in series, as represented in Fig. 11, no current would flow in the connecting links *x*, *y* and *z*. For this reason, the generator windings are interconnected either as shown on the left of Fig. 12, which is commonly called "delta-fashion,"* or as shown on the right, which is called "Y-fashion" or "star-fashion." In either case, only three terminals are brought out from the winding, as indicated in Fig. 12.

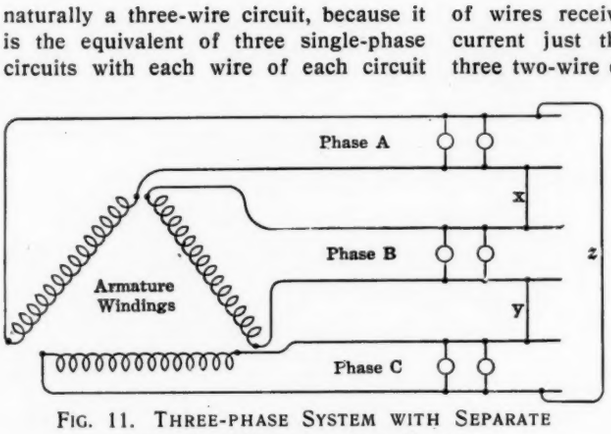


FIG. 11. THREE-PHASE SYSTEM WITH SEPARATE ARMATURE WINDINGS AND CIRCUITS

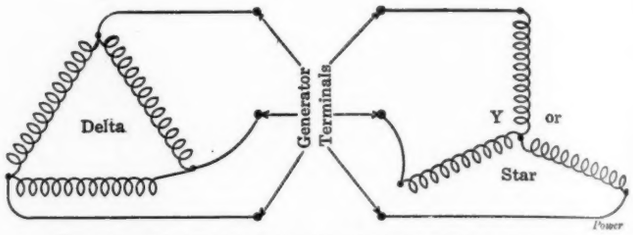


FIG. 12. STANDARD CONNECTIONS OF THREE-PHASE ARMATURE WINDINGS

It would be possible to connect three two-wire circuits to these three terminals on the generator, as shown in Fig. 13, but that would be uneconomical and unnecessary. Instead of that complicated arrangement, only one wire is connected to each generator terminal, as shown in Fig. 14, and the load between each pair of wires receives its own voltage and current just the same as though the three two-wire circuits were used. Each wire of the three-wire circuit must have a cross-section 1.73 times the size of the cross-section of each wire of the three two-wire circuits, because it carries the combination of the two currents which two wires carried in the three-circuit arrangement; the reason for this is that the two currents are out of phase one-third of a cycle, and the current formed by combining them is therefore only 1.73 times as great as each of the separate currents†.

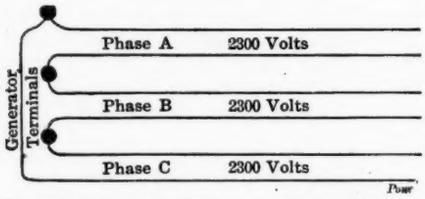


FIG. 13. DISTRICT CIRCUITS FROM A STANDARD THREE-PHASE GENERATOR ARMATURE

From the foregoing it should be clear that there is no similarity whatever between the three-phase three-wire circuit and the ordinary direct-current and single-phase three-wire circuits. In the former, the voltage is the same between any two of the three wires and the load is divided into three equal parts, one-third being connected between each two wires, as indicated in Fig. 14. In the latter two systems, the voltage between the middle wire (the three-phase system has no "middle" wire) and each outside wire is one-half the voltage between the two outside wires and the load is divided into two equal parts, each connected between the middle wire and one of the outer wires. The two-phase three-wire circuit is nearer the single-phase and direct-current circuits in its character, there being the same division of load into two equal parts, connected between a middle wire and two outside wires; the differences are that the voltage between outside wires is only 41 per cent. higher than the single voltages between the middle and each outer wire, and the current in the middle wire is 41 per cent. greater than that in each of the outer wires if the load is equally divided, as it should be; consequently, the middle wire can never be "neutral"—it always carries more current than either of the others, whereas the middle wire of the direct-current and single-phase circuits carries no current at all when the load is equally divided between the two sides.

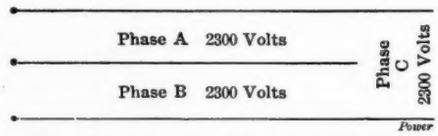


FIG. 14. THREE-PHASE THREE-WIRE CIRCUIT

*Because the diagram of current "vectors" is a triangle with equal sides, like the Greek letter "delta."

†The current formed by combining two equal currents of any polyphase system is equal to $\sqrt{n}$ × one of the separate currents, n being the number of phases in the system. $\sqrt{3} = 1.732$.

Lamp Ground Detectors for Power Circuits

BY J. M. ROW

Most engineers are quite familiar with the method of connecting ground-detector lamps as shown in Fig. 1. In this scheme, a ground on the positive wire is indicated by the lamp *A* burning brighter than *B*, the difference between them depending upon the resistance of the ground; if a dead ground occurred on the positive wire, the lamp *A* would get its normal voltage while *B* would be short-circuited. A ground on the negative wire would be indicated by the lamp *B* burning brighter than *A*.

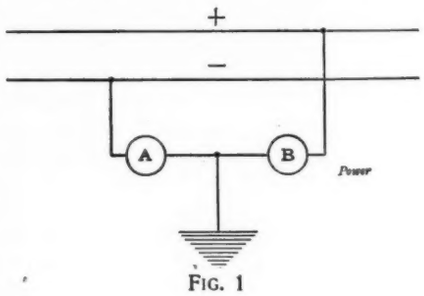


FIG. 1

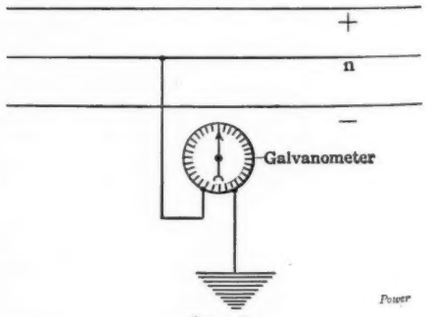


FIG. 2

In the three-wire system the detection of grounds is a little more complicated

than in the ordinary two-wire system. Fig. 2 shows one method, which, however, is not very satisfactory for the reason that it will not show the condition of the insulation of the neutral wire. This system is very little used and requires no explanation further than to say that a ground on the positive main will deflect the galvanometer in one direction while a negative ground will give an opposite deflection.

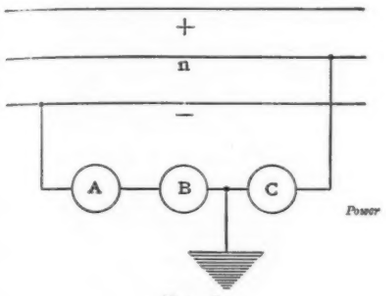


FIG. 3

Fig. 3 shows a simple way of connecting lamps for detecting grounds on the three-wire system. Under normal conditions the three lamps will burn dimly, because each lamp receives one-third of its normal voltage. A ground on the positive main will cause all the lamps to burn bright; a neutral ground will extinguish the lamp *C* while *A* and *B* will burn a little brighter, receiving one-half their normal voltage. A ground on the negative main will extinguish *A* and *B* while *C* will burn at full candlepower. This method, while simple, has obvious disadvantages in practice, and is very little used.

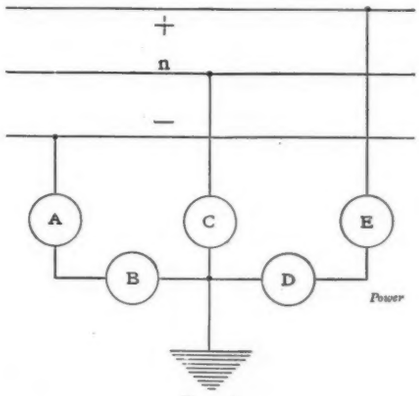
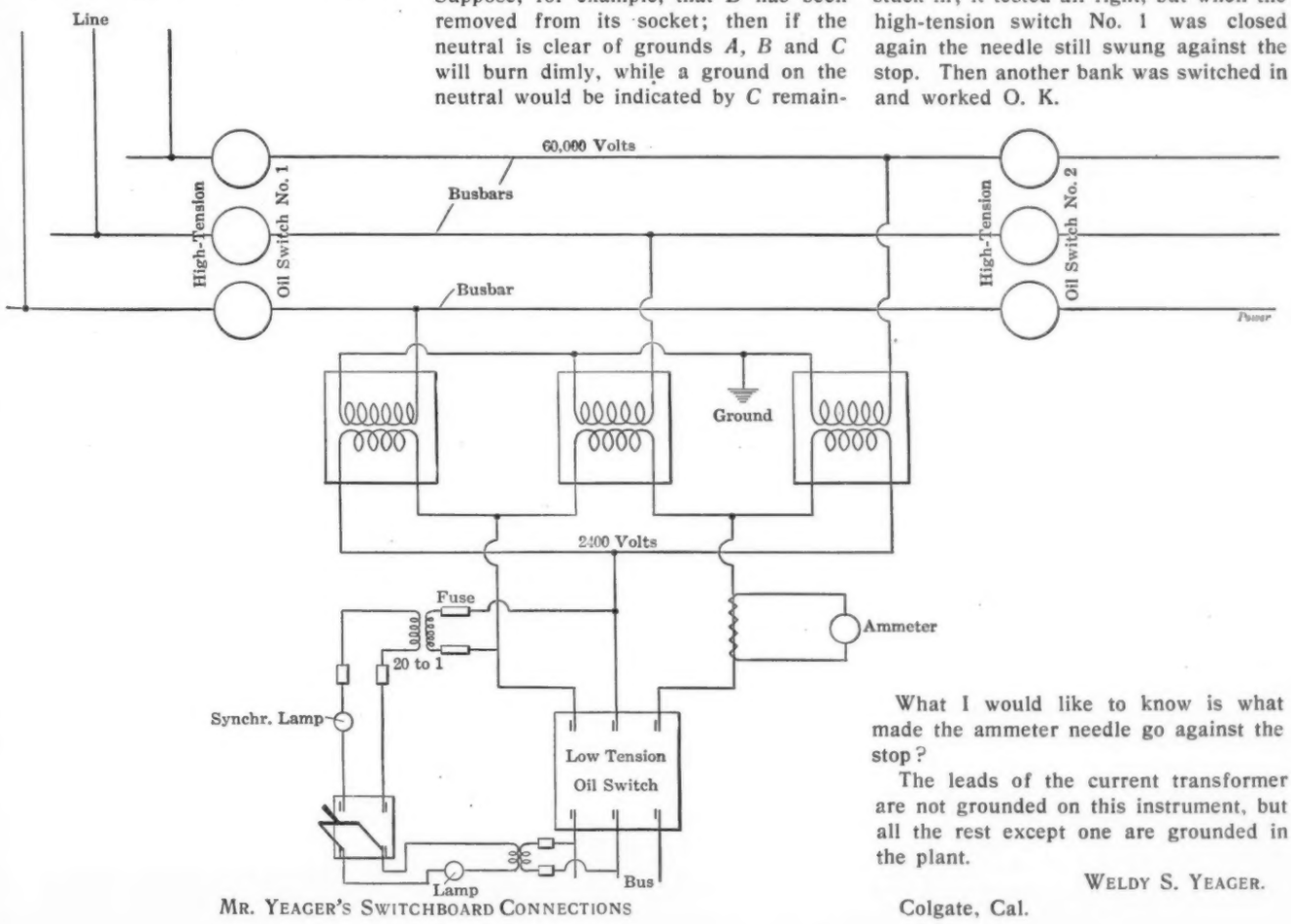


FIG. 4

The most reliable method is, perhaps, that shown in Fig. 4. The lamps *A* and *E* are placed on the back of the board and the others are on the front. Under normal conditions *A*, *B*, *D* and *E* all burn with half voltage while *C* is dark. A positive ground brings *A*, *B* and *C* up to normal voltage while *D* and *E* are extinguished; a negative ground lights *C*, *D* and *E* and leaves *A* and *B* dark. To detect a neutral ground it is necessary to open one side of the circuit, which may easily be done by unscrewing a lamp. Suppose, for example, that *D* has been removed from its socket; then if the neutral is clear of grounds *A*, *B* and *C* will burn dimly, while a ground on the neutral would be indicated by *C* remaining dark while *A* and *B* continued to burn dimly.

It is very essential that all of the lamps in any ground-detector system be of the same candlepower and voltage, to prevent unbalancing the system and to give proper comparative brilliancy.



MR. YEAGER'S SWITCHBOARD CONNECTIONS

LETTERS

Where Did the Current Come from?

One Sunday morning recently a short-circuit occurred on a 60,000-volt system, causing one of the lines to be switched out. It is always necessary here to test a line for current before going on, for in case of trouble each line goes to a certain division to be looked after.

On trying this line for current, the high-tension oil switch No. 2 was opened as well as the low-tension oil switch; and when the high-tension oil switch No. 1 was closed the needle of the ammeter on the low side went over against the stop. High-tension oil switch No. 1 was opened and the meter needle fell back to its proper position; upon closing No. 1 switch again, the needle went over against the stop again. Then high-tension switch No. 1 was opened and the low-tension oil switch was tested for fear one leg was stuck in; it tested all right, but when the high-tension switch No. 1 was closed again the needle still swung against the stop. Then another bank was switched in and worked O. K.

What I would like to know is what made the ammeter needle go against the stop?

The leads of the current transformer are not grounded on this instrument, but all the rest except one are grounded in the plant.

WELDY S. YEAGER.

Colgate, Cal.

Gas Power Department

Fuel Quality and Engine Output

By Cecil P. Poole

Everything worth while in the gas engine and producer industry will be treated here in a way that can be of use to practical men.

There is amongst operating engineers a rather general misunderstanding of the effect which the heat value of a gas-engine fuel has upon the ability of the engine, most men supposing that the capacity of the engine is roughly proportional to the heat in a cubic foot of the gas on which it works. Of course, gas-engine designers know differently, but this article is not written for gas-engine designers. Even old hands at gas-engine

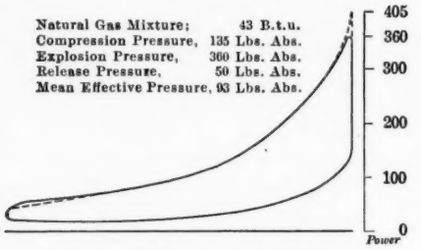


Fig. 1. Natural-gas Diagram

operation have assured me solemnly that an engine running on natural gas would do three to five times the work that an engine of the same bore and stroke would do on producer gas, if the mechanical construction would only "stand the strain," and an experienced erector spent a futile half hour once trying to convince me that the ratio between the capacities of the two classes of engine (natural and producer-gas) was at least two to one.

The reason that views so far astray are held by men who are in position to learn better is that they lose sight of

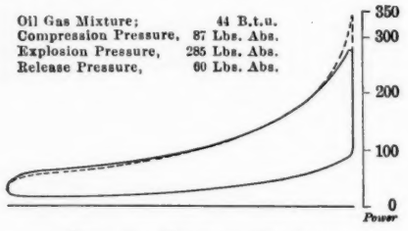


Fig. 2. Oil-gas Diagram

the facts that it is the heat value of the *mixture*, not the gas alone, that counts for doing work, and a rich gas requires so much more air to burn it than a poor gas does that the difference between a mixture of rich gas and air and one of poor gas and air is less than 50 per cent. in the worst practical cases.

Another reason why an engine running on rich gas will not do very much more than one running on poor gas is that with the poor gas the compression is higher than with the rich gas, which increases the efficiency of combustion.

The data given in the accompanying tables show clearly how the various gases commonly used compare as to heat value of mixture, working value in the engine, etc. The gases chosen for the comparison are natural gas of about 900 B.t.u., oil gas of 534 B.t.u., suction-producer gas of 137 B.t.u. and blast-furnace gas of 94 B.t.u. per cubic foot. The natural gas is of the following composition:

Hydrogen	2.2 per cent.
Marsh gas	92.6 per cent.
Olefiant gas	0.4 per cent.
Carbon monoxide	0.5 per cent.
Carbon dioxide	0.3 per cent.
Nitrogen	3.7 per cent.
Oxygen	0.3 per cent.
Total	100.0 per cent.

Its calculated heat value is 906.8 B.t.u. per cubic foot at 32 degrees temperature and atmospheric pressure.

The oil gas is of the following composition:

Hydrogen	51.8 per cent.
Methane	33.0 per cent.
Ethylene	4.2 per cent.
Carbon monoxide	4.2 per cent.
Carbon dioxide	1.4 per cent.
Nitrogen	5.2 per cent.
Oxygen	0.2 per cent.
Total	100.0 per cent.

The calculated heat value per cubic foot at 32 degrees and atmospheric pressure is 533.9 B.t.u.

The composition of the producer gas is as follows:

Hydrogen	14.0 per cent.
Methane	0.8 per cent.
Carbon monoxide	26.0 per cent.
Carbon dioxide	5.0 per cent.
Nitrogen	54.0 per cent.
Oxygen	0.2 per cent.
Total	100.0 per cent.

Its calculated heat value per cubic foot at 32 degrees and atmospheric pressure is 137½ B.t.u.

The blast-furnace gas contains:

Hydrogen	2.6 per cent.
Carbon monoxide	26.0 per cent.
Carbon dioxide	9.4 per cent.
Nitrogen	62.0 per cent.
Total	100.0 per cent

Its calculated heat value at 32 degrees and atmospheric pressure is 94.16 B.t.u. per cubic foot.

Theoretically, a cubic foot of the natural gas would require 9.02 cubic feet of air to burn it, but as it is impossible to make every atom of gas come in contact with its portion of the air when the exactly correct quantity of air is put in the cylinder or the mixing chamber of the engine, a considerable excess of air is required, just as in the case of an ordinary furnace fire under a boiler. A very efficient proportion of air to gas, under operating conditions, is 13 cubic feet of air to each cubic foot of natural gas.

A cubic foot of the oil gas requires, theoretically, only 5.13 cubic feet of air to burn it, but in an engine it is necessary to put in about 7 times as much air as gas. Similarly, a cubic foot of producer gas requires 1.03 cubic feet of air theoretically and about 1.4 actually, while

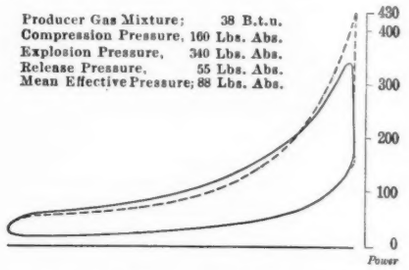


Fig. 3. Producer-gas Diagram

blast-furnace gas needs 0.69 cubic foot theoretically and about 1 cubic foot practically. These figures, with the resulting heat values of the several mixtures, are given together in Table 1 for convenience in comparison, and the comparison is instructive. It should be noted that while natural gas has nearly ten times the heat value of blast-furnace gas, a practical mixture of natural gas and air contains only 38 per cent. more heat per cubic foot than a practical mixture

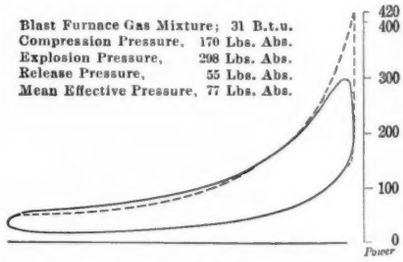


Fig. 4. Blast-furnace Gas Diagram

of blast-furnace gas and air; and oil gas, which has less than 60 per cent. of the heat value of natural gas, makes a mixture a little higher in heat value than that made with natural gas and air in practical proportions.

The heat values of the mixtures are given for two conditions: the standard of 32 degrees and atmospheric pressure, which is commonly used for making comparisons, and the practical condition of

240 degrees (700 absolute) temperature and 13½ pounds absolute pressure, which is a fair average for actual engine cylinders.

"utility factor" of the engine and the gas with which it works.

This "utility factor" ranges all the way from 50 to 75 per cent., and it can

TABLE 1. HEAT VALUES OF GASES AND EXPLOSIVE MIXTURES.

Kind of Gas.	Gas Alone.	Theoretical Mixture.			Practical Mixture.		
	B.t.u. per Cubic Foot.	Air per Cubic Foot of Gas.	B.t.u. per Cubic Foot of Mixture.		Air per Cubic Foot of Gas.	B.t.u. per Cubic Foot of Mixture.	
	Cold.*		Cold.*	Hot.†		Cold.*	Hot.†
Natural gas	906.8	9.02	90.5	59.9	13.0	64.8	42.9
Oil gas	533.9	5.13	87.1	57.7	7.0	66.7	44.2
Producer gas	137.5	1.03	67.8	44.9	1.4	57.3	37.9
Blast furnace	94.61	0.687	55.8	37.0	1.0	47.1	31.2

*At 32 degrees Fahrenheit and atmospheric pressure.
†At 240 degrees Fahrenheit and 13½ pounds absolute pressure.

TABLE 2. WORKING PROPERTIES OF PRACTICAL MIXTURES.
At 240 Degrees Fahrenheit and 13½ Pounds Absolute Pressure.

Fuel.	Compression			B.t.u. per Cu.Ft.	M.E.P. Theoretical.*	Probable Utility Factor.	Probable M.E.P.
	Ratio.	Pressure.	Factor.				
Natural gas	5.9	135	3.75	43	161	0.58	93½
Oil gas	4.2	87	3.50	44	155	0.55	85
Producer gas	6.5	160	3.85	38	146	0.60	88
Blast furnace	7.0	170	3.95	31	123	0.63	77½

*Mean effective pressure that would be obtained by calculation if the utility factor were 100 per cent.

This is only part of the story. The compression has to be considered also in estimating what an engine will do, and there must be taken into account the fact that gases containing considerable hydrogen will ignite more readily and the flame will spread through the mixture more rapidly than when gases containing little or no hydrogen are used. These two features are on opposite sides of the balance sheet; that is, higher compressions, giving better efficiencies, can be used if the gas contains little or no hydrogen, but quicker ignition and flame spreading are obtained with gases containing more hydrogen, giving a greater pressure rise just before the expansion stroke. Furthermore, the quicker the ignition of the mixture in the cylinder, the higher will be the maximum temperature of combustion, and, on the other hand, the higher this temperature, the more heat loss to the water jacket will there be, and therefore the lower will be the mean effective pressure in comparison with what it would have been if there had been no heat loss at all.

These various uncertainties cannot be calculated at all; they can be only lumped together as an unknown loss and referred to as a certain percentage of the heat in the mixture that does not help to raise the pressure when the mixture is ignited. A convenient way to look at the matter is to say that theoretically the gas ought to do so much work, but actually it only does such and such an amount of work; therefore the power shown by an indicator diagram is only a fraction of the power that the gases should develop, and this fraction or proportion may be called the

be determined only by a series of tests with the actual engine and the actual fuel to which it is to be applied. The meaning of the "utility factor" can best be explained by a simple example. Suppose the heat value of the mixture and the effect of compression showed that the mean effective pressure should theoretically be 160 pounds, but the engine only showed an average mean effective pressure of 80 pounds; then the "utility factor" would be 0.5 (½) because one-half of the theoretical mean effective pressure is obtained.

It is not feasible to explain without rather complex mathematics how the compression pressure affects the amount of mean effective pressure obtainable with a given fuel; the reader will simply have to take my word for it that the higher the compression pressure, *within a short range*, the higher will be the mean effective pressure with the same fuel and the same proportion of air to gas. This effect can be represented by a number which, when multiplied by the heat per cubic foot of hot mixture, and by the utility factor, will give the mean effective pressure*. This number, which may appropriately be called the "compression factor," ranges from about 3 to about 4½, according to the compression and the piston speed.

The mean effective pressure, as explained in the foregoing paragraph, is equal to *Heat per cubic foot of mixture* × *Compression factor* × *Utility Factor.* Table 2 gives appropriate compression ratios and pressures for the four practical mixtures described in Table 1, together with the compression factors corresponding to the respective compression ratios; it also gives the calculated mean effective pressures that would be obtained by using a utility factor of 100 per cent. for all four mixtures, just for the sake of getting a comparison without any guessing, and also the calculated mean effective pressures with utility factors of 0.58 for natural gas, 0.55 for oil gas, 0.60 for producer gas and 0.63 for blast-furnace gas. With the different utility factors, it will be noticed, the mean effective pressures do not differ greatly, and even with the utility factor of 1 throughout, the mean effective pressures differ far less than the heat values of the gases.

To enable the reader to get a sort of pictorial idea of the foregoing comparison, the diagrams in Figs. 1 to 5 have been plotted from the figures given in Table 2 and data which those figures involve. The dotted lines show the diagrams that would be made if the heat transfer from the inside of the cylinders to the jacket water were uniform throughout the expansion stroke. The solid lines show the diagrams that would probably be made by actual engines under the conditions assumed; in plotting these solid-line diagrams the distribution of the heat transfer throughout the stroke was calculated on the basis of the continuous drop of temperature and increase in wall surface which occur as the piston moves outward. No correction of the compres-

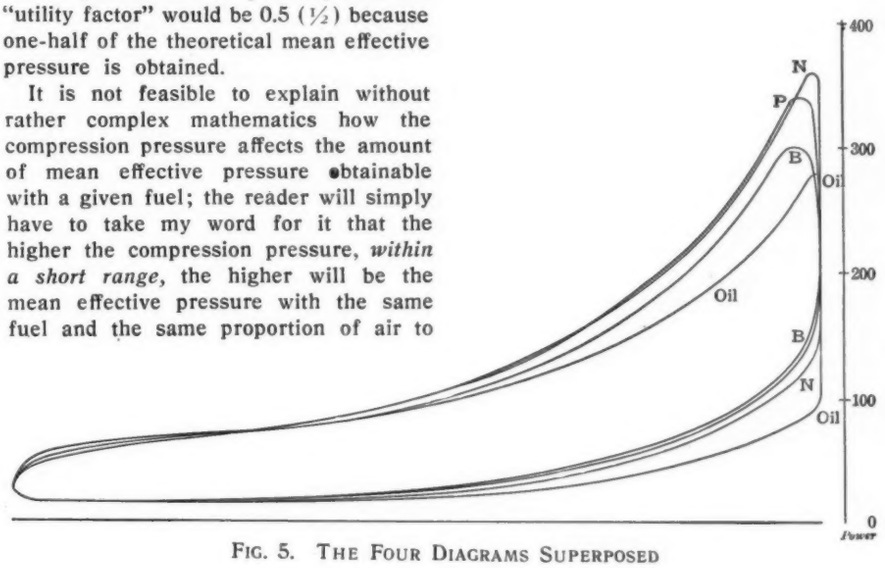


FIG. 5. THE FOUR DIAGRAMS SUPERPOSED

*For a detailed discussion see "The Gas Engine," by the author of this article.

sion curve was attempted because the diagrams are too small to show the discrepancies.

In Fig. 5 the four diagrams are combined for direct comparison, but a really satisfactory comparison is out of the question because the lines cannot be made fine enough to show even moderate differences on the scale to which the diagrams must be reduced for printing. The initials *N*, *P* and *B* are used to identify the curves of the natural-gas, producer-gas and blast-furnace gas diagrams, respectively.

The reader must not suppose that the figures given for mean effective pressure are necessarily those which would be obtained with an actual engine; there are so many variable influences which affect the mean effective pressure that it is absolutely impossible to calculate it beforehand within even 10 per cent. of accuracy. The point of ignition, location of the igniter, condition of the piston rings, shape of the combustion chamber, velocity of the piston and rate of jacket-water flow all have much influence on the mean effective pressure developed with a certain gas and a certain proportion of gas to air. The figures show, however, an accurate comparison of the mean effective pressures that would be obtained under certain conditions, if these conditions could be made exactly the same for all four of the mixtures considered, and they illustrate the wrongness of the idea that the heat value of the gas is even a rough measure of the power that the engine will develop when using that gas.

Some Surprising Figures

In estimating the relative cost and operating expenses of a steam- and gas-power equipment for a small hotel plant recently, F. W. Dean, of Boston, reported that the gas-power equipment would cost more than double the steam equipment, although gas producers were not considered, and the cost of operation, including fixed charges, would also be about double. The plant was to contain one 35-kilowatt and two 100-kilowatt units. Here are his figures:

ESTIMATED FIRST COST.

	Steam.	Gas.
Engines and generators (also steam boilers)	$ 8,408	$20,950
Foundations	525	685
Piping and auxiliaries	2,500	3,000
Wiring and switchboard	1,390	1,390
Incidentals, 5%	677	1,375
	$13,500	$27,400

ESTIMATED ANNUAL OPERATING COST

	Steam.	Gas.
Coal, at 7.3 lb. per kw.-hr. for 4 months and 2 lb. for 8 months of the year = 372 tons at $4.34	$1614	.....
Gas, at 35 cubic feet per kw.-hr. and 65c. per 1000	.....	$4504
Fixed charges, 13% on investment	1755	3562
Engineer	720	720
Oil, waste and supplies	450	500
Totals	$4539	$9286

The estimate of $3000 for gas-engine piping covers also the muffler, which is not highly expensive, but the corresponding figure of $2500 for the steam plant covers piping, heaters, pumps, etc. The question of utilizing the waste heat of the gas plant during the eight months when the exhaust steam was expected to do heating was apparently not considered.

Small Gas Engine for Intermittent Service

By James H. Beattie

Within the past few years a broad field has been opened up to the gas engine for small powers where the steam engine is too expensive by reason of the fact that the demand for power is more or less intermittent. In my own city there are large numbers of small plants, mostly under 25 horsepower, driven by internal combustion engines. The class of work includes planing mills, kinding-wood mills, grist mills, structural-steel shops and carpet-cleaning plants. One reason for the wide use of these small engines is that the city authorities permit the use of gas engines in many places where the use of steam would not be permitted; but the main reason lies in the economy of the gas engine over steam. This economy is not altogether in fuel consumption but is also assisted to a large degree by the saving in attendance.

For instance, one plant was driven by a 10-horsepower gasolene engine at a cost of 90 cents per day for fuel. There is no special attendant, one of the regular men looking after the engine. This engine replaced a steam outfit of the same size which required the services of an engineer at $2 per day. The cost of fuel was about the same in both cases. In another case a planing mill is driven by a 25-horsepower gas engine at a cost of $30 per month for gas, no special attendant being required. When I visited the plant the engine room was closed and locked, and I was assured that the only attention given was to fill the oil cups every few hours and about 15 minutes each day put in by one of the men cleaning the engine and making adjustments. In another case a 10-horsepower engine drives a clay-working plant at an expense of $5 per week for gasolene and oil; no special attendant is employed, one of the regular men looking after the engine. He assured me that a few minutes each day was all that he found necessary to keep the engine in good order.

The saving in all these cases over the use of steam is so great that it leaves no doubt as to which is the most desirable in such cases. It would perhaps seem that an electric motor would be satisfactory where current is available, but in several cases where motors have been compared with gas engines it has been shown that a good gas engine is able to deliver power at less than half the cost of the motor current, and the gas engine has proved just as reliable as the electric motor. In one case with which the writer is familiar a 20-horsepower motor was replaced by a gas engine with the result that the operating costs were reduced to less than half, while the repair bill was reduced from a considerable figure for the motor to almost nothing for the gas engine.

The gas engine has made possible the operation of many small industries in this locality which otherwise could not continue because their demand for power is intermittent and the expense of keeping a boiler under steam would be too great.

CORRESPONDENCE

Moral: Keep the Clearances Equalized

A bad click in one of the gas engines under my charge caused no small amount of worry and annoyance. The engine is of the twin-cylinder, single-acting type, rated at 100 horsepower. The click occurred at about the end of the working stroke and as the two-to-one gear had a tooth broken at this position it was naturally supposed that the noise was in the gear. A new gear was obtained and substituted for the defective one, but the click remained. It could be heard more distinctly at one cylinder than at the other and sounded as if it might be a broken ring, but the rings were all in good shape shortly before when the piston was examined, and it was not probable that one had broken since then. No amount of lubrication either of the cylinder or valves seemed to help matters in the least, and in desperation it was decided to take out the piston; but just before stopping the engine I noticed that the counterbore was worn bright on the bottom side and on a closer examination it was found that the piston was traveling far enough to allow one of the rings to drop into the counterbore at the end of each stroke.

The piston was unscrewed from the crosshead a distance equal to the width of the ring, and the click ceased.

The engine had been run about seven years and the continued taking up of the crosshead and crank-pin brasses had not been compensated for; this caused the piston ring to overtravel, as mentioned. While no serious results occurred, it is easy to imagine what might have happened if this had been a double-acting engine, and the experience points out strongly the necessity of taking great care that the clearance of a double-acting cylinder is always equally divided between both ends of the cylinder.

Earl Pagett.

Coffeyville, Kan.

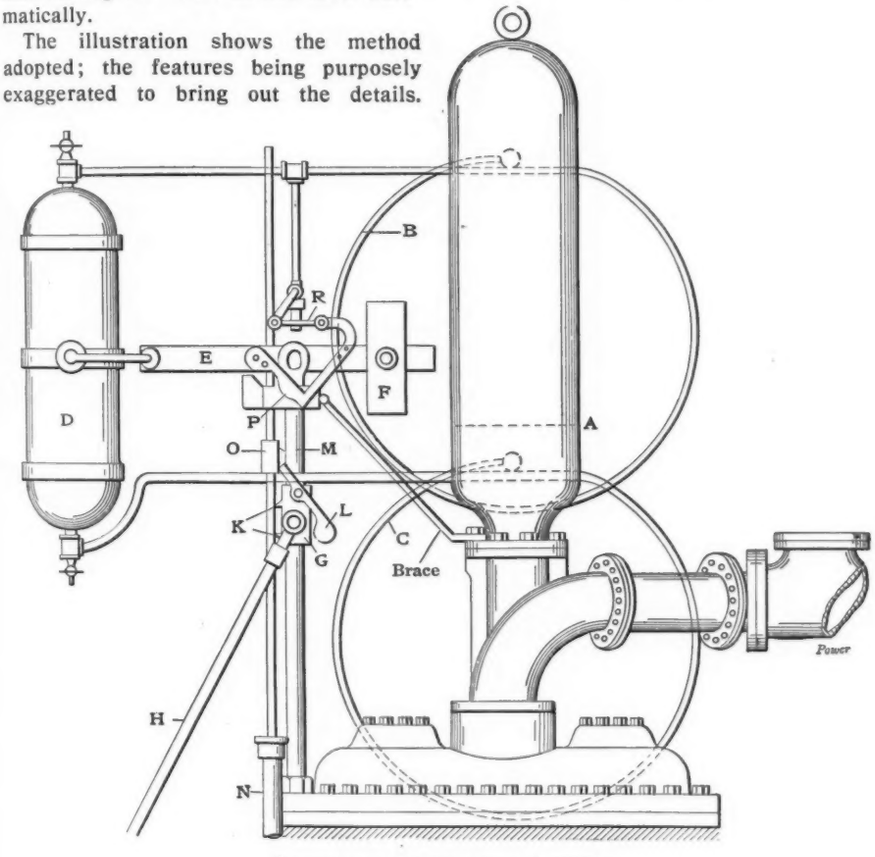
Readers with Something to Say

Practical information from the man on the job. A letter good enough to print here will be paid for. Ideas, not mere words, wanted.

Automatic Pump Regulator

It was noticed in several residential sections of a town, supplied by a certain pumping station, that every stroke of the pump could be distinctly heard in the water pipes. This, no doubt, was mainly due to a faulty system of layout. In an attempt to remedy the trouble, the pump discharge pipes were altered to secure the benefit of two air chambers instead of a single chamber which had been used up to this time. It was found that the change proved beneficial, provided that sufficient air was maintained in the chambers; which required that the water be held at a certain level. It was then that the engineer devised a scheme for maintaining the water at that level automatically.

The illustration shows the method adopted; the features being purposely exaggerated to bring out the details.



AUTOMATIC REGULATING DEVICE

The two air chambers (only one of which is shown, the other being in line with it) were connected together by two lines of ½-inch pipe. From a tee in the middle of each emanated the two pipe coils *B* and *C* which connect with the top and the bottom of the copper tank *D*. Thus this tank is in direct communication with both chambers, but to prevent the circulation of the water and air from one to the other, a check valve was placed on each side of the tee. Thus, equalization of air in the chambers takes place through the copper tank. The tank is suspended and balanced by the lever *E* and weight *F*, respectively. It is obvious that as the water in the chambers rises, the dead weight of the tank increases, and as it is suspended on a knife-edge fulcrum and the pipe coils are of a diameter which allows much spring, its plane lowers until the lever *E* comes to rest on the stop directly under it. Inversely, as the water level lowers in the chambers, the tank becomes lighter than the weight *F*, and is raised by it. The standard upon which the tank and weight are balanced forms a guide rod for the crosshead *G*. This is connected to the crosshead of the pump by *H*, thus converting a horizontal into a vertical motion. Contained in the block *G* are the two spring latches *K*, the upper one of which is controlled by the weight handles *L*. Near the top of this is the small steel screw *M*. A homemade air pump built on the principle of a bicycle pump is located at *N*. The air discharge (not shown) connects to the pipe *B*, while *O* is a block pinned to the air-pump rod, and is of a size to fit between the two latches *K*. A right-angled strip *P* is riveted to the lever *E* as shown. The operation is as follows:

The steel screw *M* is so adjusted that when the balance lever *E* is horizontal as represented in the sketch, it will come directly in contact with the projection on strip *P*, thus causing the upper latch *K* to disappear within the block *G* and allowing *O* to pass, just exactly as the latch of a door will disappear when the handle is turned. When, however, the tank *D* lowers, *M* passes under the projection, and the latch is now allowed to hook the block *O* of the air pump, and air is pumped into the chambers until equilibrium of the tank and weight is restored. On the other hand, when too much air is present in the chambers, and the tank *D* rises above the position shown, the link *R*, connected to *P*, will open the small petcock, allowing the escape of surplus air until the equilibrium is again restored and water is at the level *A*. The successful working of the apparatus depends on restricting the movement of the tank to within narrow limits.

L. M. LESLIE.

Cambridge, Mass.

Experience with an Air Compressor

A short time ago the superintendent of a plant in a nearby town requested me to come over to determine, if possible, what was wrong with his air compressor. It was a duplex steam and two-stage air machine running at about 150 revolutions per minute and controlled by a combination speed and pressure governor. The air receiver had not yet arrived and the compressor was discharging direct into the line. When running at full speed it took considerable time to get the pressure up to 90 pounds and after this point had been reached the compressor continued to run at about 100 revolutions per minute. When the machine was shut down the pressure in the air line fell very slowly, which indicated that the leaks in the line did not amount to much; so it was plain that the compressor was not handling as much air as it should.

While the compressor was running I opened the safety valve on the intercooler and there was no pressure in it, showing that the first-stage cylinder was not compressing any air. We according-

ly took out the discharge valves and found that one was broken and the rest so badly stuck to their seats that it took considerable work to get them loose, most of them having been closed tight against their seats. One set of inlet valves was also taken out and cleaned, and when all the valves had been overhauled and replaced, the compressor was started again.

This time it worked satisfactorily, and when the pressure was up to 90 pounds it slowed down to 25 revolutions per minute.

GEORGE DREYER.

Gibsonburg, O.

Receiver Steam Used to Heat Feed Water

As a general rule in the ordinary condensing plant using reciprocating engines, the exhaust steam available from the auxiliaries is sufficient to heat the feed water up to 200 degrees, unless the people running the system want a turbine vacuum on a reciprocating engine, which, of course, results in a low condenser temperature, and consequently low feed-water temperature. However, when you install one or two turbines in a plant, the feed-water temperature must be sacrificed in order to gain a high vacuum and there seems to be only one side to this question, and that is, get the vacuum.

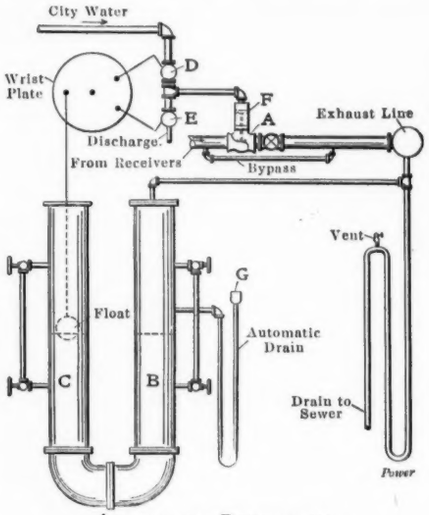
Electric-driven auxiliaries are also a factor in the low feed temperature question, caused by the illusion a great many people have, that if the prime mover is economical, everything driven by it must also conduce to higher economy. For instance, in large modern plants the exciters are usually driven by motors, perhaps the circulating pumps are motor driven, generally the wet-vacuum pumps are direct-coupled to motors and sometimes the stokers are also driven in the same way. As a result the only exhaust steam available for heating feed water is from the dry-vacuum and feed pumps and a little calculation will show that this is not sufficient, although doing a considerable share.

Some concerns, however, are waking up to this phase of the situation, and are installing turbo-exciters, which is a step in the right direction, these small machines being, of course, noncondensing. Yet many engineers have come into such places and wondered why the auxiliary machines are not condensing. Before installing our steam-driven exciter we were confronted by this same cold-water proposition and the way we overcame it was to use steam from the receivers on our reciprocating engines to help out with the other exhaust.

The regulating device used for this purpose is shown in the accompanying illustration.

The bleeders from all the receivers are led into a 4-inch pipe, a gate valve, check valve and open drip being placed at each receiver bleeder line. The object of the gate valve is to shut off connections to the 4-inch line in case it is necessary to repair the check valve. The check valve is to prevent steam being forced up into the receivers of an idle engine. The open drip is used in starting up, to let out the water from the receiver when there is not pressure enough to force it out into the 4-inch line.

The 4-inch line is about 30 feet below the receivers and as we carry the same pressure in all three receivers, this head takes care of whatever difference exists and forces the water out into the 4-inch line. Between the exhaust line and this line is a valve *A* (see sketch) with a 2-inch cylinder on top of the bonnet. The valve stem is extended up through this cylinder and a piston *F* attached to it.



AUTOMATIC REGULATOR

The valve is of the globe type with the 4-inch line connected to the under side of the disk as shown, so the pressure in this line has a tendency to keep the valve open. A ¾-inch bypass is installed around the valve to keep the 4-inch line free from water if the valve should remain closed too long, the bypass being open all the time. On the basement floor is a U-pipe consisting of two 10-inch pipes *B* and *C*, 10 feet long and connected by elbows at the lower ends.

The pipe *B* is closed at the top with a blind flange and is connected to the exhaust line by a ¾-inch pipe. The U-pipe is filled half full of water so it is evident that the pressure in *B* is the same as that in the exhaust pipe. Our heaters work on the induction principle, and consequently the pressure in the exhaust pipe is about equal to that of the atmosphere. Since the leg *C* of the U-pipe is open at the top, the water level in the two legs will vary with the pressure in the exhaust. A float is placed in the leg *C* and is attached by a rod to the wristplate. On the wall are two ½-inch chronometer valves *D* and *E*, and the levers of these valves are connected to the wristplate as shown. On top of the 4-inch valve *A* is a cylinder and piston, as before stated, and the top side of the cylinder is connected to the chronometer valves. The city water line enters valve *D*, and the discharge is through the pipe in the bottom of valve *E*.

The operation of the device is as follows: If the pressure in the exhaust line falls below a predetermined amount, the water level rises in pipe *B*, and falls an equal amount in pipe *C*. This lets the float down and it operates the wristplate, closing the valve *D* and opening valve *E*. This allows the water on top of the piston *F* to escape and the steam pressure under the main valve seat raises the disk and discharges the steam from the receivers into the exhaust line until the pressure in the line comes up to normal conditions, in our case about 1 inch above atmospheric pressure.

When the pressure in the exhaust lines rises above the predetermined amount, the water is forced down in the leg *B* and up in leg *C* and the float rises again, operating the wristplate. In this movement the valve *E* is closed and valve *D* is opened, admitting city water under 125 pounds pressure on the top of piston *F*, thus forcing the disk in valve *A* to its seat and thereby shutting off the steam.

In the ordinary running of this device, it would soon fill up with water from the exhaust pipe, but the small drain pipe shown attached to leg *B* prevents this. If the water level at atmospheric pressure is as high as the pipe outlet, it will run out; while if the water level gets higher, due to low pressure in the exhaust pipe, no water will run out because the atmospheric pressure at the outlet is higher than the pressure within the leg. If the pipe is full of water and the pressure in the leg *B* is higher than atmosphere, then the cup *E* takes care of the water forced up into the outlet leg of the drain.

E. H. LANE.

Kansas City, Mo.

Safety Blocks and Safety Appliances

While doing some work on an engine of the Corliss type I asked the engineer in charge, if the speed of the engine had ever been changed. He replied that it had been set to run faster but he did not know by how much. Seeing no means at hand for adjusting the speed, I asked him how he had done it, and he promptly told me that he had lengthened one reach rod and shortened the other.

At first I doubted his word but upon investigation found conditions such that had the governor belt broken, the engine would certainly have speeded up, as the safety blocks were in such a position

that they could not have disengaged the hooks in case of such an emergency.

Safety blocks are all right, but in cases where they are not in perfect working order the lives of men are in danger as well as the damage to property.

It should be the duty of every factory and mill owner to provide means for stopping the engine from any place in the mill should an accident occur. There are several good machines of this kind on the market that are worked in connection with the speed-limit governor, and may be had at a very reasonable figure compared with what accidents usually cost.

W. A. MUELLER.

Decatur, Ill.

Novel Indicator Reducing Motions

The following indicator-reducing motions are described, not because of any particular merit, but rather for their ingenuity and novelty. Fig. 1 illustrates a form which many will recognize as a modification of that originated by Armand Stevart. It consists of the wooden pulley *A*, pinion *B* and rack *C*. The two former

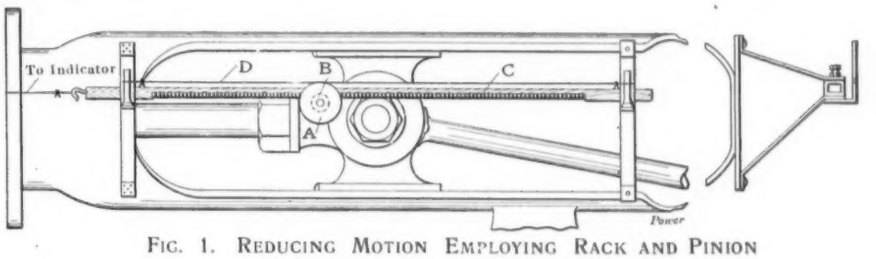


FIG. 1. REDUCING MOTION EMPLOYING RACK AND PINION

are secured to the crosshead, and their reducing value depends on the ratio of their respective diameters. Around the pulley are made a few turns of strong cord *D*, the two ends of which, when pulled taut, are secured to the end brackets, one of which is shown at the right of sketch. This causes the pulley and the gear, which is bolted to it, to rotate when the crosshead moves. Now if the gear were allowed to rotate the pulley, that is, if the cord *D* were removed, it would, of course, make a definite number of revolutions, depending on its pitch circumference, while traveling the length of the rack. If, however, it was prevented from making the full number of revolutions, then the rack would be carried along with it a distance equal to the difference in pitch circumference between that which the gear actually revolved, and that which it ought to have revolved. For instance, if the rack is 27 inches in length (equal to the stroke of the engine) and the pitch circumference of the gear is 9 inches, and it was allowed to make but 2⅔ revolutions while traveling the full length, then the rack will move

$$27 - (2\tfrac{2}{3} \times 9) = 3 \text{ inches.}$$

Should the cord of the indicator be attached to the rack, then a 3-inch diagram would be the result. From the foregoing it will be apparent that when the cords of pulley *A* are connected up, gear *B* must move the rack a certain distance owing to the greater circumference of the pulley. The size of pulley for a given sized gear to produce a given size of diagram can be found from the formula:

$$D = G\left(\frac{S}{S - C}\right)$$

in which

D = Diameter of pulley,
G = Pitch diameter of gear,
S = Stroke of engine,
C = Length of diagram.

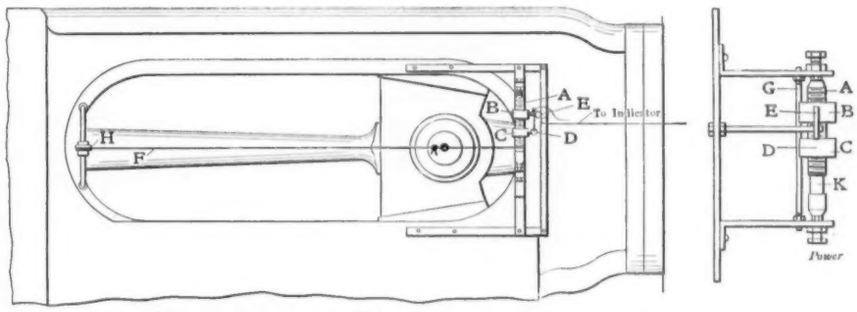


FIG. 2. REDUCING MOTION USING BOLT AND NUTS

Fig. 2 shows a form of reducing motion in which a common 2-inch bolt is the means employed. The bolt *A* is mounted perpendicularly on a bracket, and has its tapered ends held by two steel set screws. One-half of it is threaded right-hand, while the other half is threaded left-hand. Each half has a nicely fitted, free running, well oiled square nut, shown at *B* and *C*. As a standard bolt of this size has 4½ threads to the inch, the nut *B* will rise about 1½ inches if prevented from turning while the bolt is revolving 7 times. So also will nut *C* descend 1½ inches. If, then, an indicator cord be attached to the pin *D*, and passed over a carrier pulley *E* which is fastened to *B*, a horizontal line, a little over 3 inches in length could be drawn on the indicator card when the bolt is revolved 7 times. In the illustration, cord *F*, being attached to the crosshead, accomplishes this. The nuts are prevented from turning by the rod *G* which acts as a guide, fitting into a V-slot, cut in each of the nuts. The driving cord *F* is continuous, and runs from the crosshead to form three turns around the bolt, then to the pulley *H* at the crank end and back again to the crosshead. The diameter of the bolt at the point *K* depends on the length of the stroke, and the size of the indicator diagram desired, as will be explained in the following example:

The engine upon which this form was used, had a stroke of 36 inches, and a diagram of about 3 inches in length was desired. This required each nut to travel about 1½ inches, and to attain that the bolt must revolve on its axis about 7 times. Dividing 36 by 7 gave the required circumference of *K* in inches, which in this case was 5.14. Dividing the result by 3.14 gave 1⅝ inches as the diameter of *K*. Of course, if this form of reducing motion was wanted on an engine running at about 150 revolutions per minute, the bolt would have to be cored out to form more or less of a shell to reduce the effect of momentum on the driving cord.

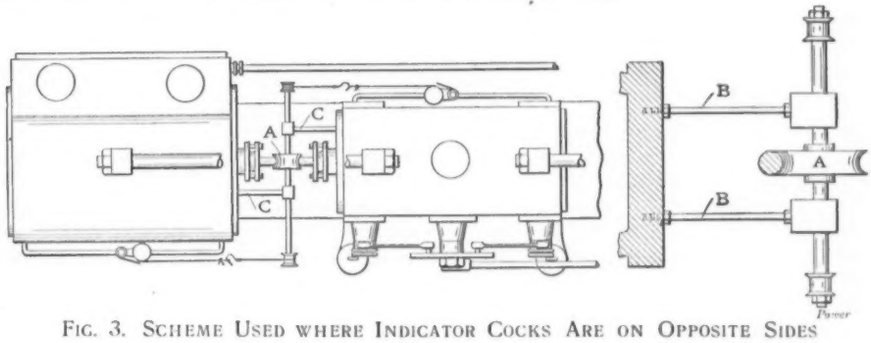


FIG. 3. SCHEME USED WHERE INDICATOR COCKS ARE ON OPPOSITE SIDES

A unique method of taking indicator diagrams is shown in Fig. 3, which represents a plan of the steam and air cylinders of an Alberger dry-air pump. It was desired to take simultaneous cards from each, but a difficulty arose from the fact that the indicator cocks are on opposite

sides, necessitating two reducing motions and two connections to the crosshead. The method shown in detail in Fig. 3 proved successful. The pulley *A* is 6 inches in its shortest diameter and is made of wood, to which strips of crocus cloth are cemented. Tension is obtained by means of the right- and left-hand threads on rods *B*. The two small end pulleys are 1¼ inches in diameter. The cords of the indicators are so coiled around them that the tension of one indicator spring balances that of the other; that is, when the spring of one indicator is being wound up, that of the other relaxes. To obtain stability and prevent end play two pieces of wood *C* were fitted between the two bearings and the cylinder heads. The length of the stroke of the air pump is 18 inches, and the number of revolutions 100.

R. O. RICHARDS.

Framingham, Mass.

Piping a Power Pump

A large quantity of water was required for daily use in a certain shop, and as there was a pure and abundant supply near at hand, it was practicable and less expensive to pump it than to purchase the amount needed from the local water company. Two direct-acting duplex steam pumps were formerly used in this service, but it was always a wasteful process, and as time passed, had grown worse for two reasons. First, the direct-acting pump does not use steam with economy even when new and in good order. Second, these pumps were old and badly in need of repairs.

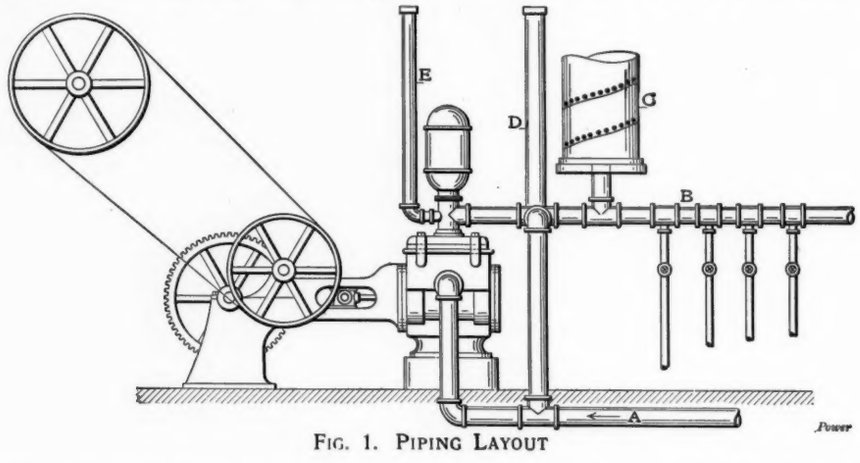


FIG. 1. PIPING LAYOUT

Accordingly a large power pump was installed as illustrated in Fig. 1. As the shop engine was underloaded, the small addition to the load caused by this change was beneficial rather than detrimental, because the terminal pressure was too low for economy and this addition raised it slightly. This probably reduced the cylinder condensation enough to compensate for the extra live steam required.

As the quantity wanted was not constant, the following plan was adopted to meet changing requirements. Water is drawn in through the suction pipe *A* as indicated by the arrow, and discharged into *B*, which is the shop-service pipe with several branches. When the quantity drawn through these outlets is less than that delivered by the pump at a constant speed, the surplus water goes into a standpipe *C*, about 40 feet high, made of spiral-riveted galvanized iron. It rests on a secure foundation not shown in the illustration.

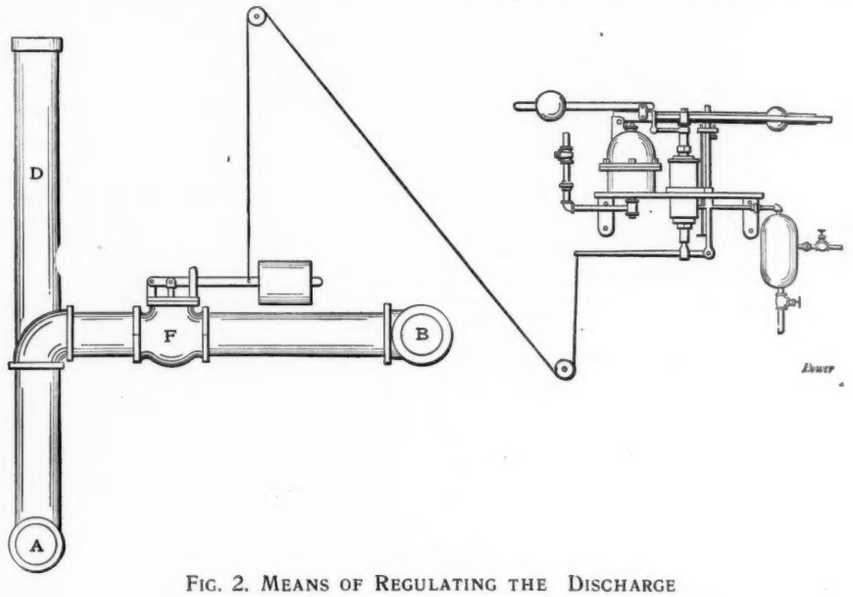


FIG. 2. MEANS OF REGULATING THE DISCHARGE

When the water level in the standpipe rises nearly to the top, the pressure at the base is sufficient to operate a damper regulator, and this in turn opens a balanced valve *F*, shown in Fig. 2. This allows water from the discharge pipe *B* to flow back into the suction pipe *A* and thus prevent the standpipe from overflowing, until more water is wanted in the shop, when the damper regulator will close *F*. This device gives perfect satisfaction and easily controls the supply under extreme variations in the demand.

The air chambers *D* and *E* were not a part of the original equipment, but the pump was noisy, and to overcome this objection the air chambers were added. They produced the desired result, and the pump is now practically noiseless, excepting the slight noise made by the gears.

W. H. WAKEMAN.

New Haven, Conn.

Gasolene Vapor

The following remarks on gasolene vapor are written with the hope that they may keep some engineer from learning them by sad experience as I have done.

The specific gravity of gasolene vapor compared with that of air is 2.5 to 3.5 when showing a reading on the Baumé scale of from 70 to 90 degrees. A 2 per cent. mixture of gasolene vapor and air would burn and might explode, while a 5 per cent. mixture makes a most dangerous explosive. At about 8 per cent. the mixture will either explode or burn, according to its staleness.

It is well to remember in connection with the above figures that gasolene vapor, being heavier than air, naturally sinks to the bottom layers, and that these figures apply to homogeneous mixtures only. Thus a very small amount of gasolene vapor may produce a very inflammable or explosive condition in the lower strata of a large volume of air, the upper portion being practically free from the vapor. This brings us to the conclusion that gasolene vapors are always dangerous, no matter what their quantity or mixture with air may be.

The liquid commercial gasolene or petrol, as it is called by the English, has a specific gravity of from 0.635 to 0.657, as compared with water. It is distilled from petroleum up to 200 degrees Fahrenheit. Gasolene allowed to stand for any length of time loses the lighter of its constituents by evaporation. Hence, stale gasolene has a higher specific gravity than that newly distilled or which has not been allowed free access to the air.

M. V. BAILLIERE.

Norwalk, Ohio.

Questions Before the House

Comment, criticism, suggestions and debate upon various articles, letters and editorials which have appeared in previous issues.

Babbitting a Main Bearing

In the March 22 issue, George C. Belling wants to know what other readers of POWER think about F. L. Johnson's statement in regard to the top of a four-part bearing.

I think it is all right, having run a 300-horsepower Corliss engine at 90 revolutions per minute (running under) for over a year with the top of the main bearing set on the engine-room floor 20 feet away from the engine.

Some time before I took charge of this plant, the main bearing of the engine in question had given considerable trouble from heating and my predecessor decided to run it a day or two with the top off. It improved matters so much that the time for putting the top back was indefinitely postponed. I had been in charge a little over a year when I put the top back and did so only on a suggestion from the superintendent that it would look better in its place than lying out on the floor. The engine is running all right with the top back in place, but it ran equally as well without the top.

REGINALD R. FORD.

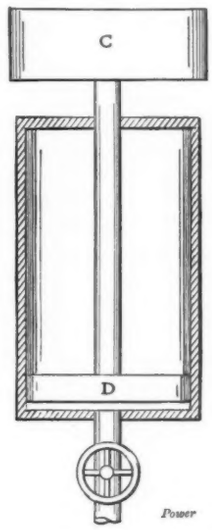
Nemour, W. Va.

Saving by Throttling Steam

Judging from his letter in the March 15 issue, A. E. Mueller's ideas on the subject of thermodynamics are, like my own, somewhat hazy. Evidently something is wrong when he figures that apparently 13,245.12 foot-pounds of work have been done with the expenditure of only 4.9 heat units. This latter figure represents the extra amount of heat required to evaporate entirely a pound of water to a pound of steam at 100 pounds absolute pressure above what is needed to evaporate entirely a pound of water at 80 pounds absolute. Suppose a piston *A* is weighted down so that it bears on a pound of water in the bottom of a cylinder with a pressure of 80 pounds absolute pressure per square inch, and suppose another piston *B* is weighted down so that it bears with an absolute pressure of 100 pounds per square inch, on a pound of water in another cylinder; then, if a fire is placed under each, when the water under piston *A* reaches the temperature of 311.8 degrees Fahrenheit it will start to form steam, and when the temperature of that under piston *B* reaches 327.6 degrees Fahrenheit it will also start to make steam. To evaporate entirely the first will require heat to the value of 1177 B.t.u., while to evaporate entirely the water under the 100-pound piston will require 1181.9 B.t.u., or 4.9 more heat units. If it were possible to convert all the heat units in each pound of water into useful work, then the steam at 100 pounds pressure would do more work than that at the other pressure to the equivalent of 4.9 heat units, which is,

$$4.9 \times 778 = 3812.2 \textit{ foot-pounds.}$$

My textbook says that heat and temperature are not the same thing, but that heat and work are equivalent one to the other. The heat of vaporization is made up of two parts, that heat which is equivalent to external work and that which is equivalent to internal work. It is with the former that the problem deals.



PISTON UNDER PRESSURE OF WEIGHT AND ATMOSPHERE

Mr. Mueller's method of finding it is manifestly incorrect as can be proved thus:

Assume the cylinder and piston in the figure herewith to be of the same dimensions and made of the same non-conducting and frictionless material as he assumed his to be. This gives us a piston having 1 square foot of area. Let the weight *C* plus the weight of the atmosphere subject *D* to a pressure of 100 pounds per square inch. Then if a pound of steam at 100 pounds absolute pressure is introduced, the piston will ascend a distance equal to the volume of the steam or 4.403 feet. In raising the weight, however, work has been done, which evidently amounts to

$$100 \times 144 \times 4.403 = 63{,}403.2 \textit{ foot-pounds.}$$

After finding the number of foot-pounds of work done, Mr. Mueller cites Peabody's steam tables for the total heat of the steam before and after doing the work, to find the number of heat units consumed. In the above example the total heat units, according to the steam tables, are the same before and after doing the work, and hence we have nothing to subtract and compare as he did. Since we cannot find that any heat units have been consumed by his method, and since we are sure that the steam and nothing else did the work of raising that seven-ton weight, "the only way it can be explained," he says, "is that some small part of the steam must have condensed and given up its latent heat of vaporization." That some of the latent heat has been given up is undoubtable, but that any of the steam must condense to give it up is questionable, for the same thing would have taken place had we used red-hot superheated steam. The proper way of calculating the number of heat units utilized in doing work is to divide the calculated foot-pounds by 778, the factor representing the mechanical equivalent of a heat unit. In the above example this would be

$$63{,}403.2 \div 778 = 80.46 \textit{ B.t.u.}$$

Further on, Mr. Mueller makes the statement that "it certainly is impossible for steam (expanded by throttling from 100 to 80 pounds absolute) to superheat while expanding and doing work." Let the weight *C* plus the weight of the atmosphere subject the piston *D* to only 80 pounds per square inch. Now, if a pound of dry steam at 80 pounds absolute pressure is introduced, *D* will rise to a hight of 5.425 feet (a distance equal to the number of cubic feet in a pound of steam at 80 pounds pressure). The heat units consumed in work will be

$$\frac{80 \times 144 \times 5.425}{778} = 79.3 \textit{ B.t.u.}$$

The total heat before doing work equals 1177 B.t.u. The total heat after doing work equals

$$1177 - 79.3 = 1097.7 \textit{ heat units.}$$

Now suppose that, instead of admitting steam at 80 pounds pressure, we allow a pound of steam at 100 pounds absolute pressure to expand under the piston *D*. It is obvious that the weight *C* will ascend the same distance as before, 5.425 feet, and that the same number of heat units 79.3 will be consumed to do the work. But the total heat of

vaporization in the steam at 100 pounds pressure is 1181.9 B.t.u.; therefore, there is left in the steam,

$$1181.9 - 79.3 = 1102.6 \textit{ B.t.u.}$$

This represents,

$$1102.6 - 1097.7 = 4.9$$

heat units more than there were when the steam at 80 pounds was admitted. As one heat unit is equivalent to about 0.48 degree Fahrenheit in temperature, the steam will be superheated to the extent of,

$$4.9 \div 0.48 = 10.2 \textit{ degrees F.}$$

I hope that "Sonny" in "Uncle Pegley's Philosophy" will soon so advance in his studies as to take a hand in controversies of this nature, for this letter proves that we are all sorely in need of some understandable literature on thermodynamics.

H. P. Everette.

Boston, Mass.

Recently, there has been more or less discussion of the topic "Saving by Throttling Steam" and some rather misleading statements have been made by those who were not familiar with the laws of thermodynamics. In attempting to set right one of these statements Mr. Mueller, in the March 15 issue, falls into one of the errors most frequent to those who are not at home with the laws of heat flux.

Mr. Mueller's problem is to find the heat lost by one pound of steam in expanding from 100 to 80 pounds absolute in a cylinder whose area is one square foot and to equate this to the mechanical work done by the steam. He makes the mistake of assuming the steam to be dry after expanding to 80 pounds and uses the volume given in the table for dry steam, which gives the result that the heat given up is only about 25 per cent. of the mechanical work done and then assumes that part of the steam condenses (which is contrary to the first assumption that the steam is dry) and that the latent heat of vaporization furnishes the remaining 75 per cent.

If we assume steam to expand adiabatically the entropy at both pressures will be equal, and the quality of the steam at the lower pressure will be the entropy at the initial pressure less the entropy of the water at the final pressure divided by the entropy of vaporization at final pressure.

In this case the quality at 80 pounds will be

$$\frac{1.5957 - 0.4520}{1.1587} = 0.9871$$

The total heat of steam at 100 pounds is 1181.4, while the total heat in the steam after expanding to 80 pounds is the heat of the liquid above 32 degrees Fahrenheit plus the latent heat of vaporization at 80 pounds multiplied by the quality.

$$0.9871\ (281.4 + 895.3) = 1161.5 \textit{ B.t.u.}$$

$$1181.4 - 1161.5 = 19.9 \textit{ B.t.u.,} \text{ or } 15{,}482 \textit{ foot-pounds.}$$

The volume of the steam at 80 pounds is

$$0.9871 \times 5.424 = 5.354.$$

The volume of steam at 100 pounds is 4.402

$$5.354 - 4.402 = 0.952 \textit{ cubic foot.}$$

With an area of one square foot the piston will have moved 0.952 foot and the work performed, assuming the average pressure to be 90 pounds will be

$$90 \times 144 \times 0.952 = 12{,}338 \textit{ foot-pounds.}$$

This shows that nearly all the heat given up by the steam is transformed into mechanical work.

The apparent variation between the two results is due in part to errors in using the difference of two nearly equal numbers in which a small variation in either of the numbers will make a large variation in the difference.

John French.

Washington, D. C.

Engineers' Wages

Having read with considerable interest the article on "Engineers' Wages" by J. W. Morgan in the March 15 issue, I want to say that there is a difference of opinion along the lines of which he writes.

In the first place, he states that in a plant where the engineer is kept busy all the time there is something wrong, it may be the superintendent, the engineer, or it may be the plant. Next, he says that the majority of engineers have time to go visiting, read newspapers and sometimes books while on duty. Further, he claims that an engineer should leave his plant troubles in the plant when leaving at night and not let them bother him until the next morning.

Suppose the employer of an engineer should ask what condition the pumps, traps, etc., were in and how much steam it took to run the pumps, could the engineer answer that they were in good running condition if he has not had them opened at least once a year? Could he tell how much boiler horsepower was necessary to run each pump if suitable tests had not been made? I am pretty sure that no engineer can get the above data by reading newspapers or books; such information is only gotten by hard work, by connecting the exhaust pipes to some suitable form of condenser and noting the results.

The cost of upkeep in any plant depends upon the engineer finding the leaks and remedying them. If this is done, the owner of the plant will then find that he is saving money by careful operation and is not losing money by bad operation, as stated by Mr. Morgan.

Keeping after small leaks in and around any steam plant requires hard work and patience but after all it pays. Where covered pipes leak, the insulating qualities of the pipe covering are destroyed.

I cannot quite agree with Mr. Morgan about an engineer's work being easy. Of course, if the engineer is simply a routine man and never does anything except what is absolutely required, his work is easy.

I think that any good engineer will make his employer's interests his interests, and whenever the problems of the plant make it necessary, he will take them home with him to study, because he can find quietness there which he cannot get in any engine room; and it will prove to be a great help to him when he takes up his duties the following day. I venture to say that a man of this kind, who is willing to devote some of his spare time to the betterment of his plant, will be the one who is picked out for the larger jobs when they come along.

At the plant in which I am employed, all high-pressure steam traps and all small pumps are tested at least once a year. When we find that they are taking more steam than formerly, we locate and remedy the trouble. By keeping after things in this way we do not have much spare time on our hands.

H. H. Burley.

Brooklyn, N. Y.

In a recent editorial it was mentioned that, "The ordinary business man does not pay any more for a thing than he has to, and hates to be open to a charge of extravagance or remark among his associates." It would hurt his feelings to be twitted as being a "good thing" because he paid his engineer more than his neighbor.

This is right to a certain extent, but let us look at the matter in a business-like way. If a man pays his engineer more than does his neighbor there is a reason why he should, because the engineer has shown the employer that he is worth more.

Let us follow an illustrative case. *A* and *B* get positions as chief engineers in neighboring plants. "The ordinary business man" hires *A* at $3.50 a day; *B* gets $2.50 a day. *A*, after a thorough inspection of the boilers, pumps, engines, and such other machinery as is under his charge, gets the amount of coal used during the last month, the amount of water evaporated, the amount of oil and waste used and the wages of each man under him, and then the output of the plant, and goes to his office, or a quiet place, and figures out just what it is costing to operate the plant. He then has a heart-to-heart talk with the general manager and gets his coöperation in the work he is going to try to accomplish. He gets it usually with the remark, "Don't try and make too great a change as the

last fellow we had ran this plant for three years and it is just the same today as it was when it was installed."

Well, *A* goes out and starts in on his boilers, takes a look all around to see that there are no leaks, either at the joints or at the blowoff valves, inspects the walls of the boilers to see that the brickwork is not cracked. If they are water-tube boilers, he looks to see that the flames are not going through the baffle plates instead of around them. Then he looks over his pumps. After this he indicates the engines, for engines three years old might need some minor repairs. Finally, he goes over any shafting that he has, fixes up any hangers which he may find to be out of line; things of that sort burn up the coal.

B, upon taking charge of his plant, looks around and does as he has always done, just keeps the plant going. He may never have a shutdown and such repairs as he finds necessary will be very few.

Six months go by; "the ordinary business man" meets his neighbor and remarks, "I am paying my engineer $5 a day; what do you pay yours?"

"I only pay mine $2.50. Why do you pay twice as much as I do; mine is a good man, and I have never had a shutdown," the neighbor replies.

"The ordinary business man" asks his neighbor over to the office, and he says something like this:

"I have been in the manufacturing business for 30 years. It is only during the last six months that I have known just what my power and lights have cost me. My engineer has taught me that there is something more to engineering than seeing that the coal bunkers are kept full and turning on the steam to the engine. I pay my engineer $5 a day and I want you to meet him."

I am a firm believer in organized labor, but it will be a hard proposition for the engineer to get his salary raised by that means. Take in an office building, for instance, the engineer might shut down the plant after asking for a raise and being refused. If he did, there would be 20 applicants for his position by members of his own organization. But, if he had shown the manager where he was making a saving of one dollar a day, and that he thought the wages were too low, I venture to say that he would get half of that small saving without any trouble.

My idea is for each engineer to keep his management posted as to what the costs are.

It is my belief that the engineers themselves are the ones that keep our profession where it is. The engineers of 20 years ago did not have the appliances of today, neither did they have the competition that we have. Because of the central power plant, it is necessary for the engineer of a plant to keep the cost of operation and maintenance down.

S. J. FOLER.

St. Louis, Mo.

I have read with interest the various discussions regarding engineers' wages and hours of labor, together with the various good, bad and indifferent suggestions as remedies. About the best remedy that I can see is for us to strive to make ourselves worth more to our employers by learning more so that we can cut down operating expenses and the cost of maintenance. A man who is any kind of an engineer or mechanic can keep lots of work out of the shop. I think that if an engineer will show his employer that he is saving him money, the employer would be willing to divide the savings with the man who is responsible for them.

We will do well to keep out of labor unions, as I cannot see how they would benefit us since we are so scattered that we could not bring enough pressure to bear at any one point to produce any effect other than to give us a lot of trouble and a bad name. We should strive to make our business a profession.

Let us form societies or associations with education as the main feature, and have them so that every man who wears the badge or holds a membership, is one of the best of those in his particular station or grade. In this way we may be able to get rid of the throttle-valve engineer and finally secure better conditions under which to work.

I hardly think it is safe or fitting to agitate legislation for license laws or examinations. When they become what the public ought to have and demand, let the public make the demand, which it will do when it finally realizes the risk it is running in placing cheap incompetents in charge of steam plants. Let our watchword be, *To earn more, learn more.*

D. W. SCARBOROUGH.

Richmond, Texas.

Operation of Boiler Feed System

The casual reader of the article under the above title in the March 8 issue, is surprised at the enormous number of valves necessary in a properly equipped feedwater line. The idea is conceived that the author must be in the valve business, and in it not altogether for his health. The valves, however, are necessary, but I believe the piping diagrams shown are open to some comment. Take Fig. 7, for example, and begin at the source of the feed-water supply, viz., the condenser discharge. From experience, I have found it poor practice to connect the two hotwell-pump discharge pipes together, for the reason that, as the hotwell is generally placed at a certain hight to provide gravity feed, the discharge water from the two pumps fights one against the other, and in case of a split condenser tube, the pumps of that condenser become greatly distressed, for a tremendous amount of water can get through a split tube. I would suggest running the discharge pipes to two separate sheet-iron hotwells connected together. This would allow for cleaning them one at a time, for, no matter how good an oil separator is installed, they will soon become filthy. Besides, when

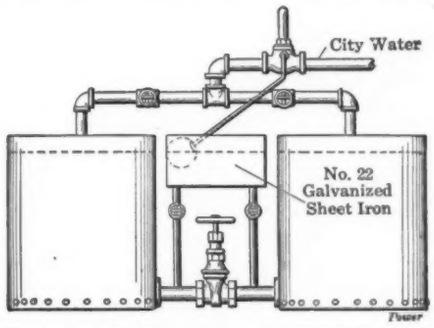


FIG. 1. ARRANGEMENT OF SEPARATE HOT WELLS

the tube ends of one condenser leak circulating water to the extent that the condensate becomes unfit for boiler use, that of the other is still available. One float valve could be arranged for both hotwells as shown in Fig. 1 herewith.

Believing that the hight of the hotwells allows sufficient seal to the pump valves while in service, I deem the two valves on the discharge pipes to be superfluous, for the piping could be arranged to discharge above the hotwell overflow, and a ¾-inch drain provided, to be opened whenever work on the pump becomes necessary.

To use the same suction pipe for both feed pumps reduces the flexibility of the system considerably, and not to have the

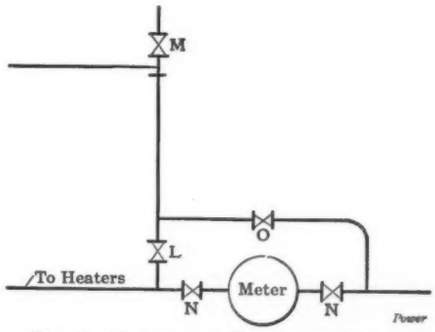


FIG. 2. SIMPLIFIED PIPING AT METER

injector connected to the hotwell is a mistake, for preference should be given to the injector rather than to the feeding of comparatively cool water through the tie line. If one suction pipe is to serve two boiler feeders, it should serve one of the pumps and the injector. With two separate suction pipes, as suggested, no direct connection between the city water main and the pumps need be made, for the float-valve line should be of a size capable of furnishing all the water

required, thus eliminating valves *S* and *T* in Fig. 7 of the original article, and simplifying things around the suction pipes. Of course, with the raised hotwell system, valves *P* and *R*, on the suction line, would be placed close to the basins, and not near the pumps as shown.

The water meter is shown piped more as a bypass than in the direct line; it seems to me that the feed water has to pass through enough of necessary elbows and bends to make it desirable to avoid passing it through any that are unnecessary. I would arrange this part of the piping as shown in Fig. 2 herewith. In this manner valve *K* is eliminated. It is true that with this arrangement the meter is bypassed when both heaters are cut out, but it is also out of service when the injector is in use in Mr. Fischer's system.

It is, I believe, rather unusual to install two primary heaters, with surface condensers. The trend is to use but one, and install that in the exhaust line of the large engine, or the one which is in the more continuous service, and to rely on a careful regulation of circulating water. Modern surface condensers will deliver the condensate to the hotwell at a temperature of but a few degrees below that due to the vacuum, and one primary heater is ample to heat the extra water admitted at the hotwell.

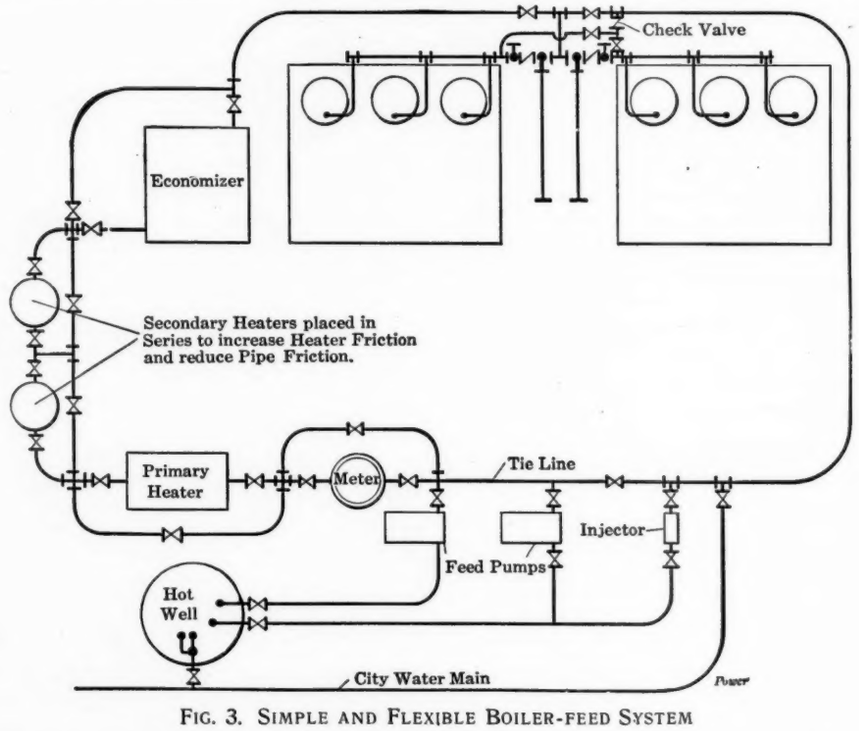


FIG. 3. SIMPLE AND FLEXIBLE BOILER-FEED SYSTEM

I fail to see the utility of the tie line shown. With two separate feed lines, and all apparatus bypassed, a plant must need be in poor condition indeed to demand cold feed through the tie line. If this became necessary, I would be tempted to use the city-water main as part of the tie. I know that no system is perfect, yet it is but right to call attention to the fact that should a leak start in Mr. Fisher's system anywhere between the valves *C*, *Y* and *M*, I doubt whether the left-hand boiler could be fed at all, unless the blowoff valves of the right-hand boiler were opened, assuming that the boiler is piped without valves on the branch lines to the drums (now compulsory in Massachusetts). Again, suppose the latter boiler to be in service, and the former to be cut out, if it is desired to fill this boiler with city water, how can it be done?

I submit the diagram in Fig. 3, not because I believe it to have superior merit, but because having criticized, it is but right that I should suggest something. The aim of the system is to obtain maximum service from the heaters, to have all portions of the feed line, up to the stop valve on boiler side of the check, accessible for repairs without stopping the feed, and to economize in pipe and fittings while allowing for ample flexibility.

L. M. LESLIE.

Cambridge, Mass.

Superheat Due to Expansion

In the issue of March 8, W. E. Crane states that if steam be expanded in a steam pipe by throttling or any cause, the total heat will remain the same, which is true, and the result is superheated steam. This is true only under certain conditions. Take, for example, steam at a pressure of 100 pounds absolute. The total heat in a pound of steam, if dry and saturated, is 1181.9 B.t.u. If this steam expands through a reducing valve down to 50 pounds absolute, the steam will be superheated about 25 degrees, assuming no losses.

Now, if we have the same steam pressure, namely, 100 pounds absolute, but the steam has a quality of 95 per cent., that is, it contains 5 per cent. of moisture instead of being dry, the total heat in a pound, under these conditions, is less, for it is only 1137.7 B.t.u. Then if this steam expands in the same manner to 50 pounds absolute, it would not be superheated, but would still be wet and have a quality of 96.7 per cent. or, in other words, would contain 3.3 per cent. of moisture.

In the first case the B.t.u. given up by the high-pressure steam to the low-pressure steam during the expansion were used to superheat the steam, while in the second case they were used to evaporate part of the moisture which the steam originally contained, and thus raise its quality from 95 per cent. to 96.7 per cent.

Mr. Crane also asks the question, "Why does not the same law apply in expanding steam in a steam-engine cylinder?"

In the case of steam expanding in a steam pipe by throttling, there is no loss of heat, except that due to radiation, which we have neglected in the above calculation, but in the case of steam expanding in the cylinder of an engine, we have entirely different conditions. In this case, the steam does work upon the piston in moving it forward and backward in the cylinder which necessitates a loss of heat. Here we have adiabatic expansion or very nearly so.

If we take the same two cases as before, first steam which is dry and saturated at a pressure of 100 pounds absolute, after being expanded down to 50 pounds absolute, will have a quality of 95.6 per cent., while steam of the same initial absolute pressure but of 95 per cent. quality will have a quality of 91.1 per cent. after expansion. By comparing the results under the two conditions of expansion, we see that the results are entirely different and therefore the same law does not apply.

E. S. LIBBY.

Chicago, Ill.

Receiver Pressure

There has been much discussion on how to determine the receiver pressure of a compound engine, which recalls to my mind an experience I once had with a high-duty cross-compound flywheel pumping engine.

It was a new plant and there were two 3,000,000-gallon pumping engines installed and guaranteed for a duty of 130,000,000 foot-pounds of work per 1000 pounds of steam. The engines were set up and run for almost six months before the conditions were such as to allow the

duty tests to be made. Shortly before these tests were run the engines were tuned up and the necessary adjustments and changes made by the engine-room force. On the day before the first official test was to be made, it was decided to run a preliminary test to see how things were, and for the first two hours we were unable to get within 5,000,000 foot-pounds of the guaranteed duty.

The engineer conducting the test began to look around for trouble and found that in balancing the load between the two cylinders he had figured on a 20-inch high-pressure cylinder instead of an 18-inch. As soon as the load was properly balanced between the cylinders, the guaranteed duty was made with 5,000,000 foot-pounds to spare.

According to this case it would seem that the way to determine the receiver pressure would be to balance the load evenly between the cylinders. The receiver pressure under these conditions would be found to be the most economical.

H. H. Berg.

Orange, N. J.

Proper Amount of Lead

Harry W. Benton, in the March 15 number, criticizes diagrams shown in Fig. 1 accompanying my letter under the above title in the January 18 issue. He cannot understand, he says, why the "end of the expansion line showing release does not go out to the end of the diagram." He also says, "The point of cutoff is very sharply shown. Altogether this diagram does not look genuine."

It is not correct to assume that that which one does not understand "is not genuine." There are many things that we may learn from each other; this is the chief benefit we derive from reading good books and technical journals. In them we get the benefit of the experiences and mistakes, as well as the successes of others, and the fact that we meet with descriptions of conditions that we do not understand is not evidence that they are not genuine. I could easily be in error. So could any other finite being. But I am not so ignorant at this late day as to find it necessary to manufacture diagrams to order, as it were.

Mr. Benton should be able to see that in this figure the back-pressure line is omitted. The late release caused the release line to conform so closely to the compression curve that, the lines being rather dim, the engraver could not separate them. This is the very simple explanation of the matter that has caused Brother Benton anxiety.

It requires but little scrutiny to enable anyone to see that the expansion line does extend out to the end of the diagram. But even if it did not, it would be nothing unusual. Any man of extensive experience with the indicator has met with diagrams in plenty where this was the case.

Just to cite a little proof, see Pray's "Twenty Years with the Indicator," pages 50 and 51, where are illustrated expansion lines that do not extend out to the end of the diagram. Again, on page 53, we find a card on which the diagrams show the expansion lines extending out beyond the end, and Mr. Pray seems to think that these last were very good examples, and I suppose he has had as much indicator experience as any man who has written on the subject.

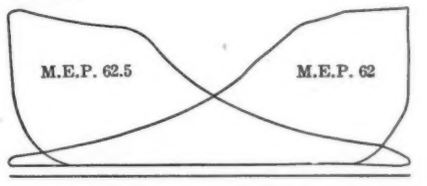
Let us be free to criticize, to seek information, and, where proper, corroboration, but except in a case which beyond question deserves it, let us be careful not to accuse a brother engineer of dishonesty.

William Westerfield.

Lincoln, Neb.

Enigmas

In February 15 issue, in a letter under the title, "Experience of a 'Trouble Man,'" I wrote the following, "A compound engine of the Corliss type will stand a large amount of fooling with, without showing appreciable difference in economy, provided the steam valves of the high-pressure cylinder and the exhaust valves of the low-pressure cylinder are not monkeyed with." I expected to be called to account for this and other statements contained therein. In the March 15 issue, there appeared an account of several queer conundrums under the title of "Enigmas," but I refrained from sending in the enigma which caused me the greatest surprise, for the reason that it formed part of my material in defense of the statements contained in the first mentioned letter. The circumstances connected with this enigma are as follows:



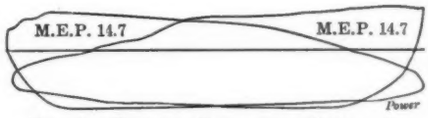
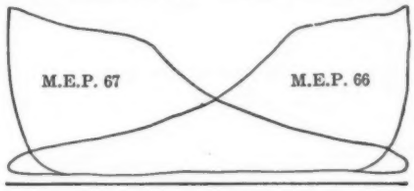


Fig. 1. Before Ring was Renewed

A 26 and 52 by 52-inch Corliss engine, is subject to loads ranging from 50 per cent. of its rated power to 50 per cent. overload. When running under this latter load, the generator voltage drops to the lowest point permitted before another engine is put on. For some time a clicking noise had been evident in the high-pressure cylinder; it was found to be caused by a broken, sectional, packing ring. When a new ring was put in, we all expected that the engine would run better and carry the overload without keeping us up on edge as to whether to start another engine or not. To our astonishment, however, the engine failed to carry even 35 per cent. overload before lowering the voltage to the prescribed limit.

How many readers would believe that more work could be gotten from a cross-compound engine having no high-pressure packing ring than from one equipped



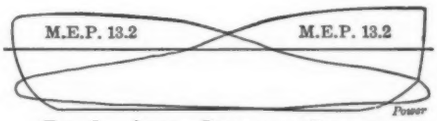


Fig. 2. After Ring was Renewed

with a good, steam-tight ring? It may, or may not, be superfluous to explain that the extra power in the former case is obtained from the high-pressure steam which escapes, mostly during admission, from the high-pressure cylinder and acts on the large, low-pressure piston. Naturally, the receiver pressure would climb up, but as it was customary frequently to adjust this, the fact that the low-pressure cylinder was getting more steam than was due to it escaped our notice.

The day before renewing the packing ring and the day after it was renewed I took indicator diagrams from the engine, and among the lot I happen to find a set in which the points of cutoff very nearly coincide in each high-pressure diagram, as shown in Figs. 1 and 2. The difference between the areas of the two sets is at once noticeable. The horsepower, figured out, is:

	High Pressure.	Low Pressure.	Total.
First set (before renewing rings)....	919.5	868.4	1788
Second set (after renewing rings)....	982.2	779.7	1762

The results show that with the cutoff at almost the same point in each, 26 horsepower more was developed with the broken high-pressure packing ring.

Now as to the economy of the engine under the two conditions, it would naturally be inferred that much more steam was consumed in the first case than in the second, but our log book which is kept with fair accuracy informs us that the engine was just as economical under one condition as under the other. The estimated average amount of coal, per kilowatt-hour, for the week preceding the renewal of the ring, was 2.417 pounds; for the first week following the renewal,

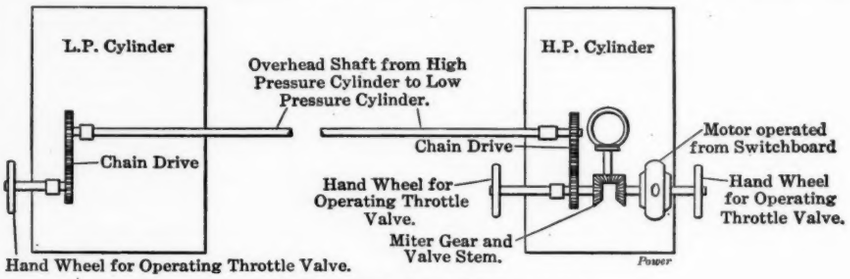
the estimated average was 2.416 pounds. The latter estimate when compared, day by day, went both below and above the other. From this I learned that it is much more imperative to keep the low-pressure cylinder in good condition than the high-pressure. The difference in horsepower between the two sets of diagrams presented is very slight, but when the engine was slowed down by an overload and carried the steam to its latest cutoff, the difference in its capacity was very noticeable.

HUGH HUGHES.

Roxbury, Mass.

Position of Throttle

There has been considerable discussion in recent issues of POWER as to the proper arrangement of the throttle-control apparatus. For a large compound engine, the figure shows an arrangement which makes it possible to shut off steam


L.P. Cylinder
Overhead Shaft from High Pressure Cylinder to Low Pressure Cylinder.
H.P. Cylinder
Chain Drive
Chain Drive
Motor operated from Switchboard
Hand Wheel for Operating Throttle Valve.
Hand Wheel for Operating Throttle Valve.
Miter Gear and Valve Stem.
Hand Wheel for Operating Throttle Valve.
Power

VALVE OPERATING MECHANISM

from a number of points. With this arrangement, it is not necessary to pass the flywheel in order to cut off steam. This is rather important when the engine is racing.

I think that this arrangement increases the degree of safety very much. The motor may be controlled from one or more points as may be found desirable.

ALDEN SEARS.

Electron, Wash.

Boiler Protection

Referring to the article "Boiler Protection," by W. R. Willard, in the April 5 number, I would like to question his line of reasoning, also the relation of pressures and temperatures in his statement to the effect that it was a wonder that the boiler did not explode. It is indeed a wonder, but I do not agree as to the danger being due to release of pressure and sudden evaporation of water as he seems to indicate when, after giving the temperatures corresponding to the different pressures, he says that had the engineer known of this he would have used his scraper instead of his hammer.

I admit that it is dangerous to lift or disturb a safety valve under the conditions stated, but believe the danger is due to shock rather than any sudden evaporation. As the pressure fell, the water would rapidly change to steam, but only at a pressure corresponding to the amount of heat it contained; no rise in pressure would be caused, as this would indicate additional heat.

The danger in liberating a quantity of water at a higher temperature than that of steam at atmospheric pressure may be shown thus: A tank may be full of cold water at such a high pressure as to cause the tank to rupture or "burst," being dangerous but hardly disastrous. But if the water were at a very high temperature, say, 350 degrees, then if it were given an excessive pressure, it would not only "burst" but would "blow up." The greater quantity of water there was, the more disastrous would be the explosion. Therefore, I differ from Mr. Willard and believe that the temperature only affects the dangers and results of an explosion but has no part in causing one. I think the real danger is due rather to shock and to the danger of the water lifting from the sheets, or priming.

WILLIAM C. THORNE.

Vineland, N. J.

Connecting Rod Crosshead Joints

William Stewart, in the March 15 issue, made some statements which surprised me. If they are correct, I know a great deal less about engines than I thought I did.

Mr. Stewart states that with the taper-and-keys joint the connection can always be observed, while with the end of the piston rod threaded and screwed into the crosshead, it cannot. In the case which was referred to in the January 11 number, the rod broke through the key slot. Now if the rod were cracked in this place for a time previous to the final fracture, how was it to be observed without removing the rod from the crosshead? If a rod has to be removed to ascertain its condition, how much easier is it to remove a taper fit than a screwed rod? I think anyone who has had experience with both kinds will prefer the screwed rod.

Mr. Stewart says that the tap is very liable to narrow down, in which event it is necessary to taper the threads on the connecting rod in order to let it into the tap for the proper length. I have yet to see a rod with a screwed end that was made with a taper. Another thing that puzzles me is his statement that, "if the clearance in the cylinder changes, the connecting rod will have to be backed out and it will be impossible to tell just how strong the connection is with the new adjustment." The only way in which the clearance is likely to change is by the wear at the crosshead and crank pins, and in taking up this wear the rod is made longer, bringing the piston nearer the head end of the cylinder. In order to equalize the clearance the piston rod should be screwed in to bring it farther from the cylinder head, which certainly would not tend to reduce the holding power of a rod with a tapered end.

W. O. PERKINS.

Bristol, Conn.

Power for Industrial Establishments

It has been generally accepted that next to water power a noncondensing plant where the exhaust can all be used for heating or other purposes is the cheapest power system that could be devised.

Acting on this idea last year I installed a 15 and 24 by 42-inch Corliss engine with the intention of running condensing during the summer and using the exhaust for heating in winter. After cold weather came on, I received word from the owners that when they stopped the condenser and turned the exhaust into the heating system the fireman had difficulty in keeping the steam pressure up. Finally, they started the condenser again and used live steam for heating. No further trouble was experienced in keeping the steam pressure up and less coal was consumed. Had I foreseen the possibility of their being able to run more cheaply that way, I should have proportioned the cylinders differently and secured a more efficient condensing engine.

In a large department store were two noncondensing Corliss engines direct connected to generators. Instead of the exhaust being used for heating, it is supplied to a low-pressure engine which drives a pump for furnishing water for the elevators. Thus, the elevators are run by exhaust steam. The owners like this plan better than that of using the exhaust for heating.

If the above be true and if a public-service company can furnish current cheaper than it can be made by the consumer, it is possible to buy current and use live steam for heating and still save part of the cost which would be required to run a private plant. Besides, all the dirt, vibration and noise which a private plant occasions would be eliminated.

W. E. CRANE.

Duluth, Minn.

Barbejat Type of Steam Turbine*

By P. Andre

This is a new type of steam turbine designed by Barbejat and being exploited by the firm of Bollinckx, Brussels, Belgium. The machine is really a combination of the De Laval and Parsons types, the high-pressure portion resembling the former and the low-pressure part being of similar construction to the Parsons turbine. In test the turbine has shown a steam consumption of 12.6 pounds per brake horsepower and a thermo dynamic efficiency of 56.8 per cent.

The firm of Bollinckx, Brussels, Belgium, is exploiting a new type of steam turbine designed by Barbezat, which may be characterized as essentially a combination of the De Laval and Parsons types. The high-pressure portion of the Barbezat turbine is a wheel on the De Laval principle, but with reduced speed, permitted by a decreased ratio of expansion. The low-pressure part of this new turbine resembles the low-pressure part of the Parsons.

Referring to Fig. 1, the steam expands from its initial pressure of about 12 atmospheres and a temperature of 300 degrees Centigrade down to about 5 atmospheres and 190 degrees, or even to 3 atmospheres and 160 degrees, in properly proportioned entrance nozzles. The kinetic energy produced by this expansion is given up to the De Laval wheel. Between this last pressure and the condenser pressure the steam expands in the stages of a reaction drum, the number of stages being less than that of the standard Parsons type.

Impulse Part of Turbine

The comparatively high speed requires that the impulse wheel shall be strongly constructed throughout. The blades are made of nickel steel and instead of being milled from solid bars, like those of the De Laval, they are rolled out in a plastic condition. Fig. 2 shows the method of attaching the blades. The rim of the rotor is given a round section over which the cavity *C* of the blade is dovetailed. To set the blades upon this rim, the latter is slotted at one or more points and the proper spacing of the blades is maintained by spacers *D* which are held by hoops *E*. Small steel plates *F* with cross-section similar to that of *D* act as spacers at the outer edge of the blades and are held in place by rings *G* and bands *H*. The blades are then welded at their outer ends to the steel rim and at the inner ends to the rotor, and the whole wheel is turned on a lathe to its proper shape shown at *B*, Fig. 2.

This form of wheel construction has proved itself both cheap and strong.

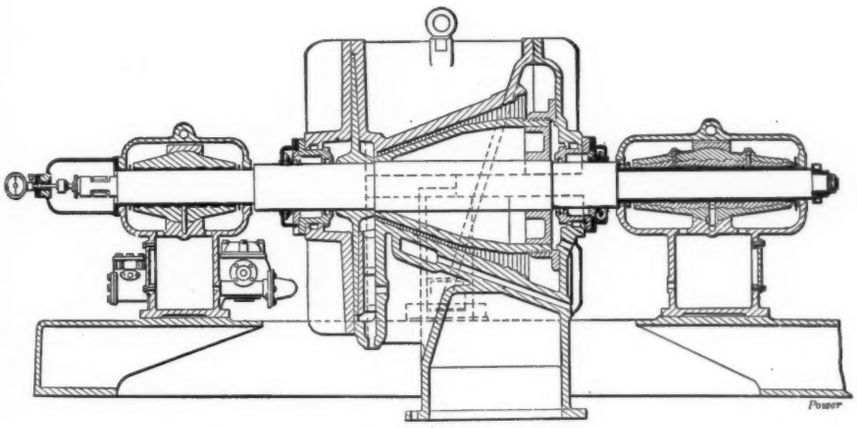


Fig. 1. Axial Section through Turbine

Reaction Part of the Turbine

The good results of the foregoing construction have induced the Bollinckx company to employ it in the members of the reaction part of the turbine. In this case the rotors with their blades are screwed together upon the shaft, forming a unit.

In the Parsons drum the degree of reaction remains unchanged from the beginning to the end of the steam expansion. Barbezat, by making the drum of the form of a truncated cone, decreases this degree of reaction gradually from the first to the last stage of the drum. This form of drum presents certain advantages, one of which is that the axial pressure can be balanced by a single labyrinth piston, whereas Parsons employs for this purpose three different pistons and labyrinths.

As is apparent in Fig. 1, the labyrinth grooves are made in the extension of the drum itself, the end surface of the drum serving as a relieving piston. This arrangement allows the axial pressure of the drum to avoid the influence of a variable condenser pressure. Since there acts upon the foot of the drum a certain pressure intermediate between the initial and final pressure of the steam in the drum, the axial pressure of the drum is counterbalanced for all loads; that is, for all admission pressures.

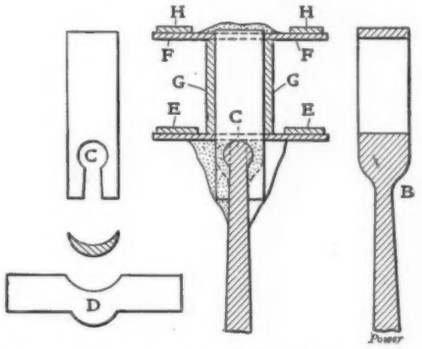


Fig. 2. Method of Securing Blades

Description of the Turbine Proper

The impulse and reaction drums are pressed on a strong shaft which rests in two ball bearings supported by the bedplate independently of the turbine casing. The shaft carries at one end a revolution counter and a speed regulator of the De Laval principle, and at the other end the clutch coupling. To adjust the position of the rotor relative to the casing and thrust bearing, one of the boxes of the bearing can be moved on the shaft by screws. The stuffing boxes consist of a metallic labyrinth packing and three-part graphite rings which are lightly pressed on the shaft by a spiral spring.

The pressure lubrication is performed by an independent double-piston pump situated on the side of the bedplate. The pump is fed with steam from the boiler and exhausts behind the impulse wheel into the turbine casing. A part of the bedplate is extended as an oil reservoir, from which the oil is pumped under 1.5 atmospheres into an air chamber, and from there into the two bearings and the regulator mechanism.

*Translated in abstract from an article in *Die Turbine*, of Berlin, by E. P. Buffet.

The steam supply is regulated by a needle valve influenced by a small piston under pressure of oil. The speed regulator operates indirectly upon the controlling valve, which is placed horizontally over the bedplate at the point of feed, directing the oil to the front or back of the auxiliary piston. As the oil pressure acts upon one or the other side of this piston, the regulating valve, and thus the steam-inlet section, is opened or closed. A lever contrivance acts as rear guide and prevents any injurious over-regulation. In order that the turbine shall be automatically shut down if the ordinary regulating mechanism or the oil pump fails to work, there is placed, at the inlet end of the turbine, a spring safety valve that cuts off the steam in an emergency. The safety valve is suspended from a hook directly in front of the turbine shaft. Opposite to this hook and at right angles to the axis, the shaft carries a governor pendulum, whose centrifugal force will, in the event of excessive speed, overcome the tension of a spring and extrude from the shaft, striking the hook and releasing the safety valve.

After the steam has passed through these various governing and safety devices, it expands in nozzles and reaches the blades of the impulse wheel. An overload valve at the side of the turbine casing permits four extra nozzles to be thrown in.

This turbine was designed for an effective power of from 500 to 600 horsepower, at 3000 revolutions per minute. The initial steam pressure required for this is 10 atmospheres, with 260 to 280 degrees Centigrade superheat, and a vacuum in the condenser of 0.08 kilogram per cubic meter.

In a test made by the manufacturers, this turbine showed a steam consumption of 5.735 kilograms per brake horsepower with a thermodynamic efficiency of 56.8 per cent.

Headless Twin Cylinder Engine

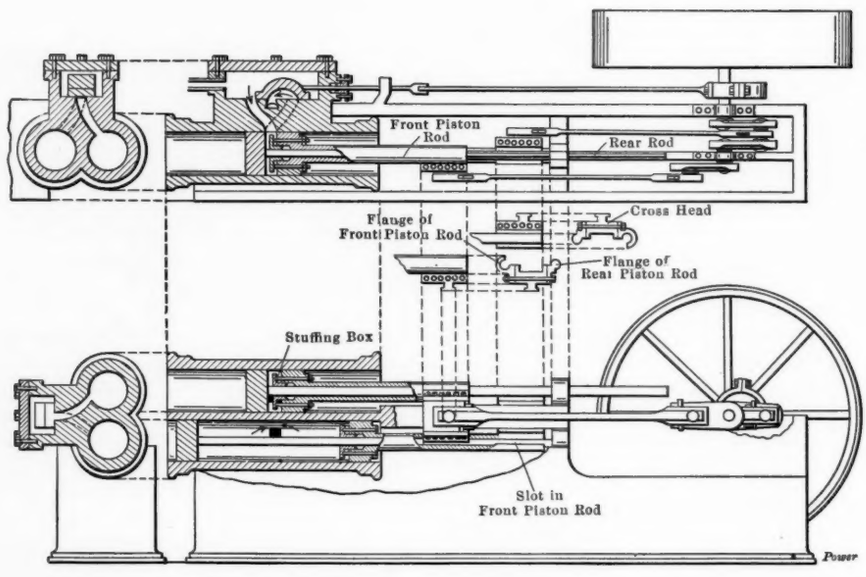
By J. C. Morris

One of the modern day freaks in which steam is admitted at the center of the cylinder and pushes against a piston on either side. The return of the two pistons to the center of the cylinder is the exhaust stroke. There are two horizontal cylinders, one above the other. While one is admitting steam the other is exhausting.

J. A. Dowling, of Biloxi, Miss., has invented an engine which differs materially from the ordinary design and to which he has given the descriptive title of "Dowling Headless Twin-cylinder Engine."

The engine, which is shown in the accompanying illustration, has two cylinders of equal dimensions. They are cast in one piece, one above the other, and are without heads except for such covering as is required to keep out dust.

In each cylinder there are two pistons; one traveling from the center to the forward end and back, while the other piston travels from the center to the rear end and back. When the two pistons are at the center of the cylinder, steam is admitted between them and they are forced in opposite directions. When they reach the ends, the steam is exhausted and they return to the center. The cycle is the same in each cylinder, but opposite in point of time; that is, during admission in one cylinder, exhaust is taking place in the other.



DOWLING HEADLESS ENGINE

It will be noted that by this method of operation, the forward piston in one cylinder and the rear piston in the other are always moving in the same direction, which direction at any time is opposite to that in which the other two pistons are moving.

The rods of the forward pistons are hollow and allow those of the rear pistons to pass through.

There are two vertical crossheads, set side by side. The piston rods from the upper front piston and the lower rear piston are attached to one crosshead while the other two piston rods are attached to the other crosshead. The crossheads are attached to the interior piston rods through slots in the outer rods. These slots, also, are of sufficient length to allow for the relative movement of the two rods.

Each crosshead has its own connecting rod attached to its own crank on the shaft. As the pistons attached to one crosshead are always moving in the opposite direction to those of the other crosshead, the two cranks are set at 180 degrees. The steam chest is on one side of the two cylinders and steam is admitted and exhausted by an ordinary D-slide valve. A flywheel and the other attachments complete the engine.

The inventor's claims are as follows:

That power is lost on the heads of ordinary engines and that this engine, having no heads, eliminates this loss.

That the engine is perfectly balanced and being free from vibration can be run at a very high speed.

That twice the power of an ordinary engine is obtained from the same quantity of steam.

[It would be interesting to ascertain upon what principles the inventor bases the above assumptions, and also to inspect the log and calculations of the test from which he claims to have obtained double power.—EDITORS.]

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Power and The Engineer

Editorial

The Boiler Disaster of the Early Morning

POWER has recently referred to the observed fact that a large proportion of the boiler disasters of explosive sort take place in factory plants just before the day's work begins, and gives some reasons and commendable precautions in such cases.

This matter is of such great importance that it deserves all the attention which it may receive. It is fortunate, of course, that at this hour there are fewer employees about the plant than there will be shortly thereafter, so that the loss of life and the injury to persons is less for this reason. Yet, on the other hand, the conditions leading to the disaster usually involve more than one boiler, making the property loss so much the heavier and the productive loss during the process of rebuilding.

The dangerous or fatal conditions are at their worst with shell boilers, and those which have large masses of water stored and heated where they may act as units. The subdivided water masses in boilers of the water-tube type are factors of safety in the combinations under consideration. It is the energy stored in highly heated water under pressure which is the danger factor, as in nearly all boiler ruptures where sudden release of pressure can occur.

The conditions of danger are furthermore augmented when the steam pipe conveying steam to the engines or points of consumption is large, and exposed to cooling effect from exposure to the air during the night. What leads up to the disaster may be related as follows:

The stop valves were closed at the boilers after the shutdown of the night before. This was done to lessen condensation loss in the pipes if the drips were left open; and to prevent the pipe filling with solid water through leaky valves if the drips were closed. It favors also the reëstablishment of pressure in the boilers under the early firing at the beginning of the day; and if any repairs or repacking is to be done after hours, the dangers are lessened if the first valves are closed as a regular practice. Hence, the pipe from all the boilers is gradually cooled with the drop of pressure in it, some water lies in all pockets badly drained, and the mass of metal and the nonconducting lagging are tending toward the temperature of the surrounding air.

In the early morning the firemen and the water tenders come to work, cleaning fires, getting full gages of water, and (it is to be hoped) paying regard to the precautions of the "commendable practice." The working pressure is gradually established in the boiler with the stop valve still closed—and properly, since the slower the heating-up process the more coal is burned to do it—and now the heat and pressure are to be opened on the pipe. Here comes the danger moment, if the person intrusted with the opening of the stop valve is ignorant or careless or inexperienced. On the pressure side of the valve are heat and stored energy; on the pipe side are lower temperature, a large volume and considerable metallic surface ready to act as a condensing area. It is only necessary now to assume and bespeak an opening of the valve slightly in excess of that suggested by knowledge and experience, enough to let steam escape through it at the high velocity with which steam rushes into a vacuum; and in a few seconds the harm is done. The steam past the valve is condensed upon the relatively cool pipe; the lowered pressure stops the action of the open drips to relieve the water, and metal and water together intensify the condensing action of the pipe and increase the rapadity of the release of pressure through the valve. The steam gas which has gathered above the surface of the water in the boiler empties itself into the waiting pipe, lowering the pressure on that surface and therefore inviting a sudden generation of steam from that water if it was hot enough from the previous action of the fire. For it must be remembered that there is a boiling point of water for each pressure; and that when a pressure is reached and maintained in a closed vessel, the process of release of steam from the water ceases, until either the pressure is lowered, or the temperature of the water is raised. In the case under assumption, the water is hot enough to boil if the pressure is reduced, but before the valve was opened there was no more room in the steam space of the boiler for any more steam gas, and so the water was storing heat under the brisk fire, but no bubbles of gas were forming and leaving the water. With the opening of the valve and the consequent release of pressure, the heated water on the instant be-

gan to boil and bubble to reëstablish the relation between pressure and boiling point. If this formation of gas in the water can be distributed through the mass, or must take place slowly enough, the boiler simply shakes and trembles—and holds fast. But if the disengagement of steam is concentrated at one point—as per example under the dome or the steam-pipe neck—the upward rush of the steam may lift the water mass as a whole. When this happens on a small scale in a laboratory vessel over a flame the phenomenon is called "bumping." The shock will be considerable, even endangering the vessel. When it happens within the shell of a boiler, and several thousand pounds of water are bumped away from the lower plates of the shell, the stresses on joints already overstrained by inequalities of temperature, may easily transcend the resisting powers of the joints. Whereupon the initial rupture takes place, a further release of pressure, a rapid formation of steam gas and an explosion in its true sense follow in inevitable order. And all is because the person who opened the stop valve on the cool pipe was careless, or hurried, or was simply "fresh," and did not realize with what forces he was meddling.

Then there is also the other set of consequences and possible disasters resulting from the happenings in the cool pipe due to the propelled energy of the condensed water, but this is another story.

Operators versus Automatics

At frequent intervals one sees the evidences of vast quantities of human ingenuity expended in producing a semi-automatic contrivance to accomplish some function ordinarily detailed to the operating engineer. In other words, we are seeking to reduce the demand on the human intelligence to the irreducible minimum. This is partly in the right and partly in the wrong direction. Where a merely perfunctory duty is to be performed, involving labor and precision, the automatic contrivance is amply justified. Such, for example, is the force-feed oil pump now universally used on large gas engines. Involving to a high degree variable human judgment and skill, the lubrication of gas-engine cylinders became so serious a matter that automatic mechanism was imperative.

An instance, on the other hand, of the superfluity of automatic mechanisms is the device for supplying a gas producer with the correct proportion of steam and air. Much has been written and many patents have been taken out in efforts to accomplish this apparently desirable object. Yet one producer builder, after developing several ingenious schemes, all workable, came to the conclusion that the producer fuel bed has so much "heat inertia" as to make it possible to operate without such means of control; and subsequent tests, carried out through a wide range, confirmed this view. In a producer plant which was working smoothly and to the entire satisfaction of the operator recently, it was noticed that one of these vapor-control mechanisms was stuck at the extreme range of its movement. An inquiry brought out the reply that "the durned thing" had never been of use and that sufficient vapor was provided for a day's run by dumping a few bucketfuls of water in the closed ashpit in the morning. Such was the ignominious end of an exceedingly clever idea.

In the operation of large gas engines, particularly on the constant-quality method of regulation, it has been a subject of much contention whether automatic means were justifiable for advancing the ignition, varying the mixture, etc., in order to obtain the most perfect combustion under all conditions of load, gas quality, etc. Every operator has to contend with more or less adjustment, oftentimes several in quick succession. It is well known that the lagging combustion on light loads (and lower compression) can be counteracted by advancing the ignition point. A sudden change in the quality of gas makes necessary the adjustment of eight butterfly valves on a tandem and sixteen in a double tandem engine. Moreover, owing to the physical impossibility of equalizing fluid friction at all points of the conducting passages, these valves are not usually set alike, each having a setting of its own for varying conditions. It is admitted that all automatic contrivances increase complication, and in careless hands may become more than useless. However, it is believed that here are two problems that need attention.

It is advisable, however, to differentiate in the matter of service. A comparatively steady load can best be handled by skilful adjustment. A violently fluctuating load cannot be handled adequately without automatics. The ignition is comparatively simple, especially with the electromagnetic type of igniter. Mixture control involves far more complexities and seems capable of solution only as to some simple adjustment, by which the governor may control, in a single movement, the entire mixture supply without disturbing the peculiarities of the individual settings. The rest must be accomplished through the intelligence of the operator. Many go about finding the most effective setting of mixture valves in the wrong way. However, experience soon teaches that the position of the governor (sleeve, or other convenient part) is the best indication of relative efficiency of working at a given load. Many engineers rig up a multiplying lever and graduated scale, such as that illustrated on page 87 of the January 11 number, to show the valve movement, but few graduate it with respect to load. The higher the governor sleeve, at a given load, the lower will be the fuel economy, so that to determine the best setting it is only necessary to "juggle" the valves until the lowest position of the governor is obtained. But if the index and scale have been previously graduated at different loads, say 100 kilowatts apart, for best mixture, it will be fairly simple to tell at a glance whether the engine is working most efficiently with the gas supplied to it. This method is not absolutely accurate, of course, but is immeasurably better than blind guesswork. It at least gives an indication which may be observed across the engine room, and a quick comparison of the load meters with the governor index will reveal the presence of variable gas and the necessity for readjustment of the valves. Here is a condition where the skilled operator is better than any automatic mechanism.

Good engineering is that which produces the most and best for a dollar. It is not sufficient that it shall produce good results regardless of costs; nor yet, that it shall be economical with impairment of results.

The successful engineer is the one who develops not only his mental powers but his physical senses as well. A striking example of this is where a broken part is in question. One man will glance at it and then go off to think it over; while another will look it over carefully, examine the fracture minutely, lift it and feel it, thus unconsciously using his physical senses. The chances are that the second man will get closer to the facts than the first.

There will be a difference of some forty degrees in the temperature of the hotwell between a vacuum of twenty-four and one of twenty-eight inches in the condenser. If this difference can be added to the temperature of the feed water, it will mean a saving of about three and one-half per cent. in the amount of fuel required to evaporate the same quantity of water.

Reducing the vacuum reduces the mean effective pressure in the cylinder and increases the temperature of the feed water. One means a loss and the other a gain. At what point do gain and loss so balance that an increase or decrease of the vacuum means loss?

If an employer is not paying his engineer as much salary as he is worth, he is not paying for value received. He is doing the engineer an injustice, beside putting in his own pocket the money that should go to the engineer's family.

Inquiries of General Interest

Questions are not answered unless accompanied by the name and address of the inquirer. This page is for you when stuck—use it.

Resetting Eccentric

If one of the eccentrics of a reversing engine should slip, can it be reset quickly and without taking off the steam-chest cover?

W. L. F.

Put the crank to which the deranged eccentric belongs on the center; put the reversing lever in full gear forward or back as the case may be for the eccentric that has not slipped; make a mark on the valve stem any distance from a fixed point on the stuffing box, then put the lever in full gear at the other end and turn the eccentric on the shaft until the mark on the valve stem is the same distance from the point on the stuffing box that it was before, taking care, of course, that both eccentrics are not in the same position.

Boiler Horsepower

Is there any short rule for determining the approximate horsepower of a horizontal return-tubular boiler?

J. C. D.

A boiler horsepower is the evaporation of 34½ pounds of water from and at 212 degrees, but the amount of heating surface required for this varies under different conditions. In the commercial rating of boilers 12 square feet of heating surface are allowed for each horsepower, but the rating has often been found to be far below the actual work done. If the diameter in inches be multiplied by the length in feet and the product divided by 660, the quotient will approximate the horsepower rating. Expressed as a formula the rule would read

$$\frac{L\,D^2}{660} = H.P.$$

Right- or Left-hand Engine

What is a right-hand engine and how is it different from a left-hand one?

F. A. W.

Standing at the cylinder end and looking toward the flywheel, the wheel will be at the right if the engine is right-hand.

Adding Cylinder to Simple Engine

How much can be saved by putting another cylinder on a simple engine, making it compound?

J. F. H.

Compounding an engine, like adding a condenser, may or may not improve its economy. If the engine is small or underloaded, compounding will probably make matters worse, while if it is of 75 horsepower capacity or more and is overloaded, compounding might increase the power for the same quantity of steam or decrease the steam consumption for the same power. It is a question that should be decided by a competent engineer after an exhaustive investigation of all of the conditions.

Valve Setting

I have a 16x48-inch Corliss engine which takes steam full stroke for several revolutions when the heavy load is on and the steam pressure in the boiler goes down, and sometimes I have to shut down the engine to get up steam. The steam valves have ⅜-inch lap and ⅛-inch lead and the exhaust valves have ¼-inch lap. Can the valve setting be improved?

S. B. R.

With the motion plate in the center of its travel reduce the lap of the steam valves to ⅛ inch; shorten the exhaust-valve connections until the valves stand open 1/16 inch and with the eccentric rod hooked on, turn the eccentric until the steam valve instead of having lead is "line and line" with the steam port.

Throw of Eccentric

What is meant by the throw of the eccentric? Is it equal to half the travel of the valve or the whole of it?

A. L. R.

The throw of an eccentric is its eccentricity, that is, it is equal to the distance from the center of the eccentric to the center of the engine shaft. As the valve travel is frequently modified by rockers or carriers, the throw is seldom one-half the travel. Throw is often erroneously defined as being twice the eccentricity.

Inverted Cylinders

In an upright engine, what is meant by inverted cylinders?

G. R. D.

An inverted cylinder is one in which the crosshead is below the cylinder. The inverted cylinder is the most common type of vertical engine.

Condenser Cooling Surface

How is the cooling surface of condensers calculated from the horsepower of the engine?

R. M. A.

Under ordinary conditions it is assumed that one square foot of cooling surface will condense ten pounds of steam per hour and the cooling surface per horsepower of the engine will be one-tenth of the number of pounds of steam used by the engine per horsepower-hour. It is common to assume that in extreme cases the engine will use a given number of pounds of steam per hour and a condenser with surface enough to condense this amount is selected.

Speed of Driving Rope

What is the best speed at which to run a manila rope drive?

D. M. C.

At about 80 feet per second. Above this speed centrifugal force begins to affect the pressure of the rope on the pulleys.

Buoyancy of Solids in Water

If a solid is immersed in water, will not the upward tendency be equal to the difference in weight between the solid and the quantity of water it displaces, it being assumed that the water is heavier than the solid body immersed?

R. S. D.

It makes no difference whether the water or the body weighs the more per given volume, the buoyant or lifting effect will be equal to the weight of the water displaced.

Injector Troubles

An injector will not feed the boiler and the trouble is supposed to lie in a plugged or leaking suction pipe. How can I tell which it is?

E. A. D.

If the suction pipe is plugged, no water can reach the injector and only steam would appear at the overflow. If there is an air leak, some water will be drawn and discharged at the overflow, but as soon as it is attempted to force the water into the boiler the stream will break as the injector will not force air into the boiler along with the water.

There is all the difference in the world between an attempt to study by mere reading, and a real study through the actual doing of work.—Prof. John Perry.

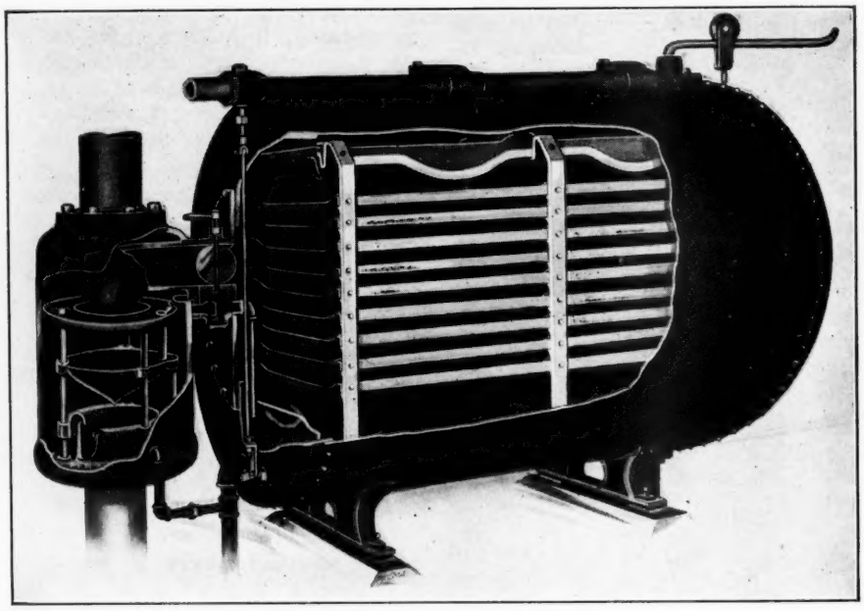
New Power House Equipment

What the inventor and the manufacturer are doing to save time and money in the engine room and power house. · Engine room news.

Hoppes Improved Induction Chamber

The accompanying illustration shows the latest improved type of Hoppes induction chamber, manufactured by the Hoppes Manufacturing Company, Springfield, Ohio.

This device is designed to afford a convenient and inexpensive means of piping Hoppes heaters so that they can be cut out of service for cleaning or inspection.



PART SECTION THROUGH HEATER AND INDUCTION CHAMBER

The device consists essentially of a cylindrical shell into which the steam enters from the bottom inlet pipe, and immediately striking against a central cone, is said to practically eliminate oil particles carried in the steam current. Flowing upward, the steam is directed into the mouth of the downwardly curved pipe by a circular, trough-shaped plate which has a central opening of approximately the same diameter as the pipe. This plate further serves to catch any oil not intercepted by the central cone, and the oil is then carried to the bottom of the chamber by the drain pipe shown.

To prevent the atomizing and spraying of the entrainment from the sides of the exhaust pipe entering the chamber, a trough is provided entirely surrounding the pipe, and a similar trough, partly filled with water, also guards the outlet to preclude all possibility of any slight entrainment creeping out. The exhaust steam entering the heater is sufficient to heat the feed water to 210 degrees Fahrenheit. It is claimed that all oil is eliminated, both from this steam, and also from the surplus passing from the induction chamber to the heating system or atmosphere, as the case may be.

In order that the steam may freely enter the heater at all times, provision is made for carrying off the air and non-condensable gases through a small vent pipe and valve, the valve being operated on the same stem and simultaneously with the valve which controls the amount of steam passing to the heater. This permits of cutting the heater in or out, by turning a single lever. The oil and moisture separated from the steam are carried off by a drain pipe placed at the side of the shell near the bottom, and this pipe is connected to the oil drain and overflow pipe of the heater. The drainage from both is readily handled by one trap which is always furnished with heaters operated under back pressure. This apparatus, with any size of exhaust pipe, can be used in connecting up any size or type of Hoppes heater by means of an arrangement of interchangeable flanges. The saving effected is proportional to the size and number of large valves and pipe fittings its use makes unnecessary.

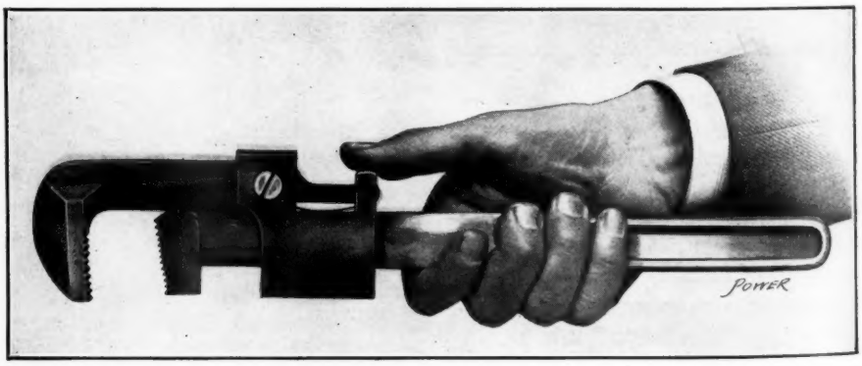
The exhaust steam enters the induction chamber through a vertical pipe and eliminates the necessity of a large, expensive ell. It also takes the place of an independent separator.

Wright Pipe Wrench

A quick-adjusting wrench for general use has recently been designed by J. F. Wright, 1334 Worley avenue, Canton, O., and is illustrated herewith.

This wrench is adjusted by a slight pressure of the thumb as indicated. A toothed rack in the lower edge of the handle engages with a toothed pawl in the sleeve and holds the adjustment. The construction of the wrench eliminates any strain being placed on the rack and pawl, as the downward pull of the handle brings an equal strain over the entire length of the sleeve.

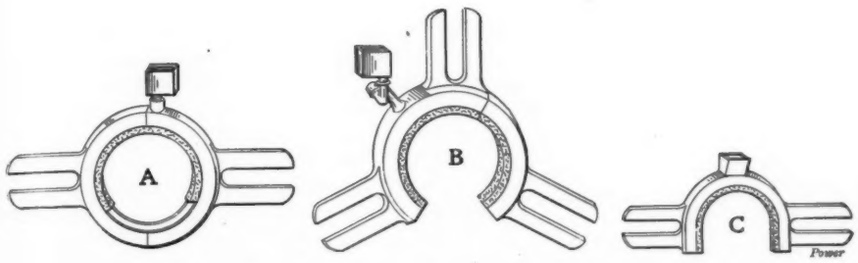
The screw in the sleeve acts as a pivot and the end of the sliding jaw, under the thumb, acts as a check, thereby distributing the strain over the whole length of the sleeve. The spring placed under the end of the sliding jaw serves the purpose of making the adjustment convenient.



WRIGHT QUICK ADJUSTING PIPE WRENCH

Peerless Oiler and Wiper

This device is so designed that it can be secured to the outside of the stuffing-box of an engine, compressor or pump. It is held in place by the gland studbolts and nuts. The brass oil cup, shown in the illustration, is connected to a small pipe, through which the oil passes to a ring of oiling felt. This felt is guaranteed to last one year and is removable. The manner of securing it is shown at *A*.



THREE TYPES OF OILER AND WIPER

The felt is permeated with oil, and as the piston passes back and forth it is sufficiently lubricated to keep it in proper condition.

The central figure *B* shows an oiler with the lower part cut away, so as to permit seeing the rod when adjusting the gland. The type of oiler shown at *C* is designed for use only on horizontal piston rods. These oilers are manufactured by the Peerless Oiler and Wiper Company, 100 William street, New York City.

Locke Nonreturn Valves

The valve illustrated in Fig. 1 is a nonreturn globe stop valve, designed for use on either vertical or horizontal pipes, and is placed in the pipe line in the position shown. It is made of extra-strong material and is designed to withstand a working pressure of 250 pounds per square inch.

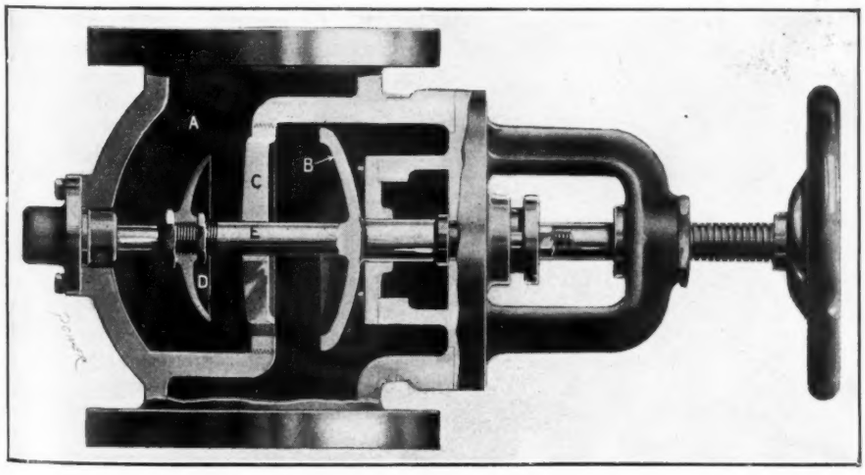


FIG. 1. NONRETURN GLOBE STOP VALVE

Steam flowing from the boiler enters the chamber *A* and forces the valve disk *B* away from the seat *C*, thus fully opening the valve. The valve disk will remain open until such time as the steam for any cause starts to flow back into the boiler from the steam main. This reverse current of steam strikes the small disk *D* with sufficient force to cause it to slide the shaft *E* forward, which brings the disk *B* to its seat and prevents the steam from other boilers flowing through the valve to the boiler having a less steam pressure.

The shaft *E* is guided in sockets at both ends and through the spider of the valve seat in the center, as shown.

Fig. 2 shows a noiseless automatic nonreturn stop valve for boiler use. There is no chattering, and beating out of the valve seat is prevented by holding the valve disk about ¼ inch from its seat and at the same time shutting off the steam.

The piston *A*, Fig. 2, comes face to face with the surrounding cylinder. It is cushioned upon the bottom of the cylinder *B* and holds the valve disk *D*, above its seat *C*, about ¼ inch. While the valve disk is being held open, the closely fitting extension disk of *D* has entered the valve-seat opening and stopped the flow of steam. This preserves the ground valve seat from being injured and keeps it in good condition for use when it is necessary to close the valve by the handwheel. In closing, the screw valve stem strikes the piston and forces the cylinder *B* down far enough to close the valve disk. When opened by the handwheel and screw, the cylinder is drawn up again, as shown.

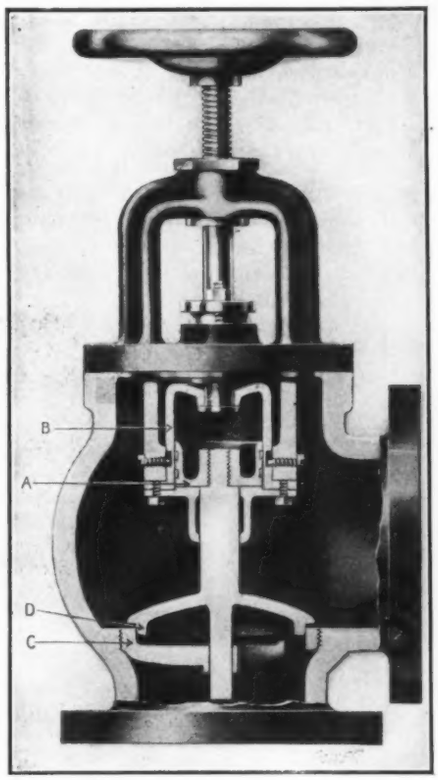


FIG. 2. NOISELESS AUTOMATIC NONRETURN STOP VALVE

These valves are manufactured by the Locke Regulator Company, Salem, Mass.

The Blake-Knowles Improved Open Feed Water Heater

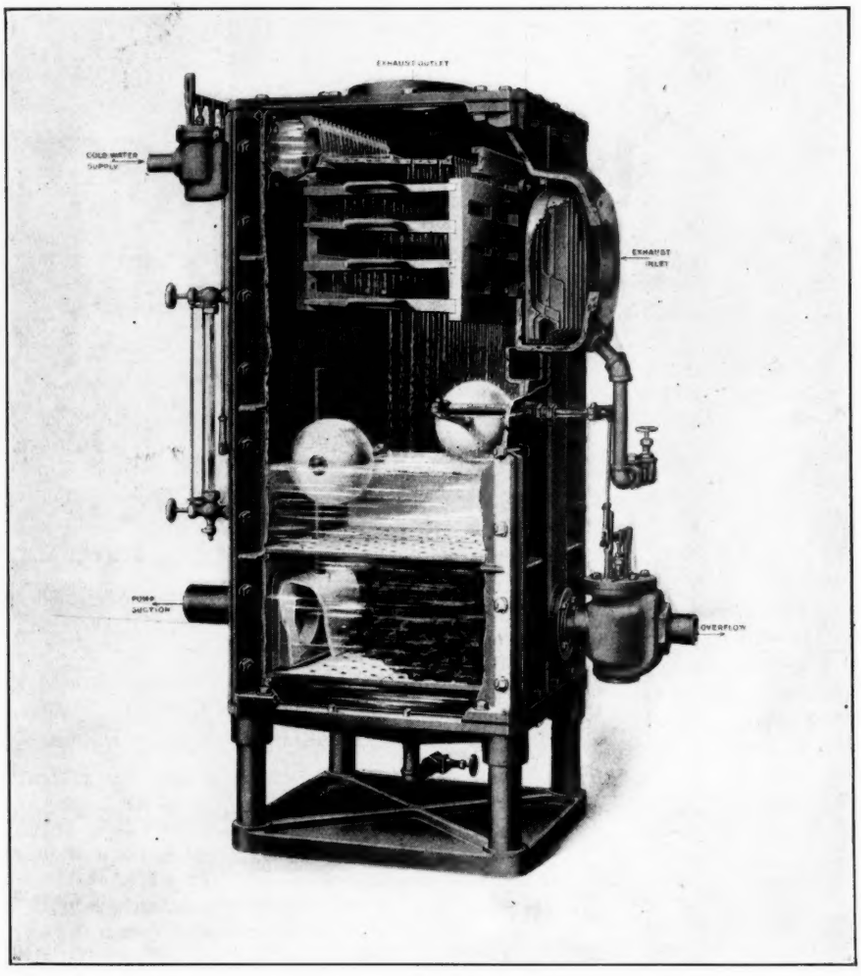
The accompanying illustration shows an improved type of open feed-water heater which the Blake & Knowles Steam Pump Works, of 115 Broadway, New York City, has recently put on the market. This heater is of new design and contains the points of advantage that the "open" method of heating boiler feed water, or water for heating or drying systems, etc., allows over other methods ordinarily in use, and embodies other features of convenience and economy of operation.

The water is heated by direct contact with the exhaust steam, the heating capacity of which is utilized at its maximum degree, and there is no drop in the temperature at which the water leaves the heater, due to any collection of mud or scale. All impurities in the water, such as sand, floating particles, etc., are retained in the filter and all scale forming carbonates, air and other gases are removed, it is claimed.

This heater extracts the oil from the incoming steam, and beside heating the water, filters and purifies it. It also contains a storage tank for recieving the water of condensation.

The apparatus consists of a vertical, cast-iron, rectangular shell, on one side of which, near the top, is located the exhaust-steam inlet. The oil separator is built into the heater body just inside this inlet and all the steam must pass through this separator before it can enter the heater. Inside the heater shell, at the top end, several shallow, removable, water trays are arranged, one beneath the other, which are slightly inclined and partly perforated. Above these trays, on the opposite side from the steam inlet, is the cold water inlet trough, out of which the water supply, conducted through an automatically controlled valve, is spilled onto the trays. The filter is located at the lower end of the shell, the material of the filter bed consisting of coke, excelsior or other similar material. This material is confined between two perforated plates and can be removed when necessary through doors provided for the purpose. Beneath the filter bed is a chamber from which the purified water is taken away by the feed pump. All the sediment collects in the lower part of this chamber and is drained away through a blowoff connection to waste. The receiving chamber occupies the space above the filter bed and is of extra large capacity so as to take care of the condensation from heating systems, etc., which is received in deluges from the traps, pockets, radiators, etc., when they discharge their contents.

An automatically controlled overflow, at the top of the receiving chamber, takes care of any dangerous excess of water. This overflow extends the full width of the shell and forms a skimmer, so that floating impurities can be skimmed off by simply holding open the cold-water inlet valve until the heater fills to this point when the impurities run off into the overflow and through the valve below, to waste. The feed-pump section is located at one side of the feed-water chamber with a vent pipe leading up into the heater body for carrying away any vapors that may collect. An outlet is located at the top end of the heater shell which is used as exhaust outlet or vent pipe, as required, depending on whether the apparatus is used as a "thoroughfare" or "draw" heater.



BLAKE-KNOWLES FEED-WATER HEATER

In operation, all or part of the exhaust steam, as may be required, enters the exhaust inlet, where, moving at a high velocity, it strikes a peculiarly punctured and bent-metal surface. The elastic steam rebounds and passes around to either side, while the oil, on account of its greater momentum, is carried through the punctured sheet against the back plate of the grating, where, out of the swirl of the steam current, it falls into the receiving well and drains away to waste.

The oil cleansed steam then enters the heater shell and fills the space around the trays where it comes into intimate contact with the water supply which is dropping from tray to tray in a finely divided condition. The water supply, entering through a float-controlled valve, fills the distributing trough which extends across the shell and overflows from a serrated edge in a thin even sheet onto the trays below. These trays are slightly inclined and partially perforated so that the water flows from one to the other over the lower serrated edge of each and through the perforations, being retarded in its progress so that it is thoroughly mixed with the steam before falling into the hot well below. Ample space is allowed around the trays so that the water in its finely divided state is highly heated.

The difference in hight between the normal water level in the hot well and the overflow level, is sufficiently great to accommodate the sudden inrush of water from the traps, returns, etc., forming in this way an adequate storing chamber for the water thus received.

Two floats, properly located in the receiving chamber, automatically control the operation of the apparatus; one, connected with the water inlet valve, regulates the cold-water supply and maintains a constant water level, at the same time meeting the demands of boiler feed-water supply, while the other, connected with the overflow valve, opens this valve when the overflow level has been reached and allows the excess water to escape to waste.

The water and condensed steam, after falling to the receiving chamber, percolate slowly through the filter bed and in this process, due to the heat of the water and the special design of the heater, the scale-forming carbonates in the water are precipitated and retained by the filtering material while the gases liberated pass out with the uncondensed steam through the vent pipe at the top of the heater. The purified and heated water drops into the settling chamber and is then pumped to the boiler. The heavy sediment collects at the bottom of the chamber and is drawn off when necessary through the blowoff connection below the heater body.

The operation of the apparatus is entirely automatic and, under ordinary circumstances, requires no attention whatever. An occasional cleaning, as may be needed from time to time, and such inspection as every engineer gives to all parts of a plant in his charge, are all that are required. Every convenience is provided for this purpose and no pipe joints have to be broken for any of the operations necessary. Pressures ranging from atmospheric pressure to five pounds above, may be carried in the exhaust line without impairing the efficiency of the heater in any way and without requiring any modification in its construction or operation.

NEW PUBLICATIONS

THE ENGINEERING INDEX ANNUAL FOR 1909. Published by the Engineering Magazine, New York City. 471 pages; 5x7½; cloth. Price, $2.

It is perhaps unnecessary to offer any words of introduction to this volume, the annuals for the past four years having met with so much favor from the engineering profession. But for the benefit of the few who may not be familiar with its purpose, it will suffice to say that the work consists of a summary of the engineering index to be found in the successive issues of the Engineering Magazine for 1909, and contains a complete record of the technical literature appearing in the various periodicals during the past year.

The present issue contains all the comprehensive features of the past issues, and in addition the classification is somewhat amplified and more complete.

The system of indexing is unique and facilitates the locating of the desired information without wading through a mass of literature of no interest whatever to the searcher. This is accomplished by grouping the subjects, first under the main divisions of engineering, then under subheads, and finally arranging them in alphabetical order. Cross-references have been freely used to afford the reader all possible clues to the information sought.

A brief synopsis is given of each topic, together with the author's name, name of the magazine in which it appears, and the price. This index forms a useful key to the mass of technical literature which may be found in any of the large libraries.

"A Problem in Piping and Fifteen Solutions" is the title of a 16-page, 6x9-inch pamphlet issued by the Harrison Safety Boiler Works. The problem was originally published in this company's advertisements in several of the technical papers, and the solutions here presented have been selected from those submitted by readers of the advertisements. The problem set is how best to connect up an exhaust-steam heating plant in which there are two exhaust mains, one from the main engine and one from the pumps an open feed-water heater and receiver and a riser to the heating system, the piping to be so arranged that the heating system shall at all times receive steam that has been purified of oil, and so that the exhaust of both pumps and engines shall be available for the feed-water heater or for the heating system as required. Provision was also to be made for cutting the heater out of service for cleaning or inspection without interrupting the supply of purified exhaust to the heating system. While many of the solutions presented are ingenious, and some of them neat and practicable, most are defective in that it would be possible to subject the heater to high-pressure steam or to stall the engine, and all of them involve the use of an independent separator and trap, together with valves and other fittings, all of which, it is claimed, can better be replaced by the new Cochrane steam-stack and cut-out valve heater and receiver. The pamphlet will undoubtedly be of interest to all who are concerned with the design, installation or operation of exhaust-steam heating systems.

General Electric Company's Annual Report

The annual report of the General Electric Company for the fiscal year February 1, 1909, to December 31, 1909, has just been received, and the main items are as follows:

Total sales billed	$51,656,631
Total orders received	54,360,562
Dividends (including dividend paid January 15, 1910)	5,214,352
Surplus for the 11 months	1,279,318.88
Surplus at end of last fiscal year	16,102,062.81
Total surplus December 31, 1909	17,381,381.69

Ruptured Tube Shuts Down Cotton Mill

On Tuesday, April 26, the Avondale cotton mills at Birmingham, Ala., were shut down on account of a ruptured tube. In No. 2, a 300-horsepower Wicks boiler, a tube in the first row next to the fire-box gave way. The tube ruptured along the weld for about 14 inches, tearing the tube loose from the bottom drum and knocking out two adjacent tubes. Nearly all of the remaining tubes were warped more or less by the heat of the brick-work of the setting after the water left the boiler. The bridgewall and firebox setting were torn out. As there were no automatic valves between boilers No. 1 and No. 2, No. 1 boiler lost a large amount of water and suffered a loss of half of the tubes by warping before it could be cut out and the water level re-established. No serious injuries were sustained by the boiler-room attendants..

SOCIETY NOTES

Two subjects of vital importance to the employing interests of the country—Prevention of Accidents and Employers' Liability Insurance—will be discussed exhaustively at the fifteenth annual convention of the National Association of Manufacturers, May 16, 17 and 18, 1910, at the Waldorf-Astoria, New York City. Attention will be given to such nationally important subjects as Uniform State Laws, Interstate Commerce, Immigration, Fire Prevention, Merchant Marine, Banking and Currency, Patents, National Conservation, Industrial Education and National Incorporation.

At a recent dinner at the Quincy house, Boston, Mass., "The American Institute of Steam Boiler Inspectors" was established with C. D. Noyes, of the Hartford company, as president. Eight insurance companies were represented, the territory covered by which comprises practically the entire United States and a considerable portion of Canada and the British provinces. The purposes of the organization are chiefly of an educational nature and membership is open to all boiler inspectors employed by the Federal, State or city governments, or by insurance companies doing business in the United States or Canada.

Members received before June 14, 1910, will be entered as charter members. Further information may be obtained from E. R. Doherty, Mutual Boiler Insurance Company, 31 Milk street, Boston, Mass.

At the thirty-third anniversary of the National Electric Light Association, which is to be held in the new Coliseum, St. Louis, Mo., May 23-27, there will be general and technical sessions, also sessions of the power-transmission, commercial and accounting sections.

Full and valuable reports by standing committees will be presented as follows: Lamps, W. F. Wells, chairman; Overhead Line Construction, Farley Osgood, chairman; Protection from Lightning and Other Static Disturbances, B. E. Morrow, chairman; Uniform Accounting, J. L. Bailey, chairman; Grounding Secondaries, W. H. Blood, Jr., chairman; Preservative Treatment of Poles and Crossarms, W. K. Vanderpoel, chairman; Meters, G. A. Sawin, chairman; Gas Engines, I. E. Moultrop, chairman; Question Box, J. C. Parker, chairman; Question Box Revision, P. Lupke and A. J. Campbell, chairmen; Solicitors' Handbook, A. Williams, chairman; Electrical Measurements and Values, A. E. Kennelly, chair-

man; Terminology, W. H. Gardner, chairman; National Conservation, D. Farrand, chairman; Insurance, W. H. Blood, Jr., chairman.

The general and technical papers to be presented include the following: Super-Specialization, by Paul Lupka; Magnetite and Flaming Arcs versus Open and Enclosed Carbon Arcs for Street Illumination (illustrated by lantern), by W. D'A. Ryan; Decentralized Steam Plants, by R. D. DeWolf; Space Economy of Turbo Generators, by Paul H. Lincoln; Gas Engine Plants for Central Stations, by Nesbit Latta; Feeder Regulators, by E. E. Lehr; A New Department in Distribution Construction Methods, by S. B. Way; Direct Current Turbo Generators, by W. L. Waters; Location of Faults in Underground Cables, by W. A. Durgin; Interesting Points about Modern Transformers, by E. J. Reed; Small Hydraulic Plant Design, by F. J. Howes; the Voltage Control of Generators and Feeder Systems, by F. W. Shackelford.

PERSONAL

F. C. Buckley, manager of the Sterling Lubricator Company, has recently left for an extended business trip throughout Europe.

J. B. Comstock, for six years with the Westinghouse Electric and Manufacturing Company at its East Pittsburg works, and for four years manager of its publication department and printing plant, severed his connections with that company in April to accept a similar position with the P. & F. Corbin Company, of New Britain, Conn.

On April 27, Dr. Rossiter Worthington Raymond was seventy years old. His friends bore the date in mind, also his thirty years of constant service as secretary of the American Institute of Mining Engineers, and on the Saturday evening following, gave a dinner in his honor at the Plaza hotel, New York City. Among the noted guests present were Dr. James Douglas, Dr. Lyman Abbott, George Westinghouse, president of the American Society of Mechanical Engineers, Sorzano de Tejada, who had come all the way from Paris as the representative of the Société des Ingénieurs Civils de France; R. T. Bayliss, vice-president of the Institution of Mining and Metallurgy of Great Britain, who had come to present Doctor Raymond with a gold medal from the institution; Dr. Frank Adams, president of the Canadian Mining Institute; John A. Bensel, president of the American Society of Civil Engineers, and many others. As Doctor Raymond arose at a late hour to reply to the numerous toasts and speeches of the evening, he was presented with a handsome silver service.

NEW INVENTIONS

Printed copies of patents are furnished by the Patent Office at 5c each Address the Commissioner of Patents, Washington, D. C.

PRIME MOVERS

ROTARY GAS ENGINE. Lincoln A. Yang, Yule, N. D. 953,788.

COMBINED EXPLOSION AND STEAM MOTOR. Wladimir Tcherepanoff, Gatchina, Russia. 953,868.

WINDMILL. Carl S. Agre, Volga, S. D. 953,890.

CURRENT MOTOR. John H. Atkins, Pasco, Wash. 953,891.

ROTARY ENGINE. Samuel A. Miles, Philadelphia, Penn. 953,964.

REVERSIBLE REVOLVING-CYLINDER MOTOR. William C. Smith, Chicago, Ill. 953,979.

ROTARY ENGINE. Nephi Bindrup, Logan, Utah. 954,162.

INTERNAL-COMBUSTION ENGINE. Eugene C. Richard, Lansing, Mich. 954,208.

EXPLOSIVE ENGINE. Edwin E. Slick, Pittsburg, Penn. 954,219.

TREAD MOTOR. Peter W. Petters, Woodland, Wis. 954,339.

VALVE. Samuel A. Biggers, McLean, Tex. 953,683.

SEPARABLE ATTACHMENT PLUG. Clarence D. Platt, Bridgeport, Conn. 953,708.

DETACHABLE PLUG. Clarence D. Platt, Bridgeport, Conn. 953,709.

PISTON PACKING RING. John J. Redner, New York, N. Y. 953,713.

BOILER-FEED REGULATOR. Howard E. Cade, Pencoyd, and David R. Knapp, Philadelphia, Penn. 953,734.

BOILERS, FURNACES AND PRODUCERS

APPARATUS FOR VAPORIZING FLUIDS. George H. Benjamin, New York, N. Y. 953,682.

CHAIN-GRATE FURNACE. Emil Bousse, Berlin, Germany. 953,684.

HYDROCARBON BURNER. Alexander O. Bradford, Boston, Mass. 953,685.

GAS FEEDING AND MIXING DEVICE. Friend E. Dillon, Martins Ferry, Ohio, assignor of one-fourth to Charles H. Copp and one-fourth to E. S. Dillon, Wheeling, W. Va. 953,820.

COMBINED STEAM BOILER AND FURNACE. William D. Plue, Rainier, Oregon. 953,921.

FURNACE REGULATOR. Orrin F. Lawrence, Canton, Ohio. 954,036.

GAS GENERATOR. Gustave A. Heckert, Munich, Germany. 954,099.

ELECTRICAL INVENTIONS

VAPORIZING AND IGNITING MEANS FOR HYDROCARBON LAMPS. Yasuke Kawasaki, Vancouver, British Columbia, Can. 953,748.

ELECTRIC MOTOR, GENERATOR AND OTHER APPARATUS. Ralph D. Mershon, New York, N. Y. 953,749.

ELECTRIC IGNITER OR BREAKER FOR GAS ENGINES. Arthur F. Clarke, Butler, Penn. 953,168.

ELECTRIC CUT-OUT. Philip T. McNally, Mandan, N. D. 954,327.

INSULATOR PROTECTING APPARATUS. Lloyd C. Nicholson, Buffalo, N. Y. 954,329.

VAPOR ELECTRIC APPARATUS. Charles O. Bastian and Albert E. Salisbury, London, England, assignors to the Cooper-Hewitt Electric Company, a Corporation of New York. 954,407.

REFLECTING LANTERN. Nathaniel H. Brown, Philadelphia, Penn., assignor to Henry S. Williams, Nathaniel H. Brown, and Morris Earle, trading as Williams, Brown & Earle, Philadelphia, Penn., a firm. 954,408.

MISCELLANEOUS TOOLS

WRENCH. William G. Royal, Hoboken, Penn., assignor of nine one-hundredths to Andrew Paul, Hoboken, Penn., and one-eighth to Elmer Thomas Wright, Pittsburg, Penn. 954,213.

WRENCH. John Johnson, Philadelphia, Penn. 954,301.

WRENCH. Harry Page, Galena, Kan., assignor of one-half to R. Homer Love, Galena, Kan. 954,335.

ENGINEERING SOCIETIES

AMERICAN SOCIETY OF MECHANICAL ENGINEERS

Pres., George Westinghouse; sec., Calvin W. Rice, Engineering Societies building, 29 West 39th St., New York. Monthly meetings in New York City. Spring meeting at Atlantic City, May 31 to June 6.

NATIONAL ELECTRIC LIGHT ASSOCIATION

Pres., Frank W. Frueauff, Denver, Colo.; sec. and treas., Frank M. Tait. Association York. Next annual convention, St. Louis, Mo., May 23-28.

AMERICAN SOCIETY OF NAVAL ENGINEERS

Pres., Engineer-in-Chief Hutch I. Cone, U .S. N.; sec. and treas., Lieutenant Henry C. Dinger, U. S. N., Bureau of Steam Engineering, Navy Department, Washington, D. C.

AMERICAN BOILER MANUFACTURERS' ASSOCIATION

Pres., E. D. Meier, 11 Broadway, New York; sec., J. D. Farasey, cor. 37th St. and Erie Railway, Cleveland, O.

WESTERN SOCIETY OF ENGINEERS

Pres., J. W. Alvord; sec., J. H. Warder, 1735 Monadnock Block, Chicago, Ill.

ENGINEERS' SOCIETY OF WESTERN PENNSYLVANIA

Pres., E. K. Morse; sec., E. K. Hiles, Oliver building, Pittsburg, Penn. Meetings 1st and 3d Tuesdays.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS

Pres., L. B. Stillwell; sec., Ralph W. Pope, 33 W. Thirty-ninth St., New York. Meetings monthly, excepting July and August.

AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS.

Pres., Prof. J. D. Hoffman; sec., William M. Mackay, P. O. Box 1818, New York City. Next semi-annual meeting, St. Louis, Mo., June 30 and July 1, 1910.

NATIONAL ASSOCIATION OF STATIONARY ENGINEERS

Pres., William J. Reynolds, Hoboken, N. J.; sec., F. W. Raven, 325 Dearborn street, Chicago, Ill. Next convention, Rochester, N. Y., September, 1910.

UNIVERSAL CRAFTSMEN COUNCIL OF ENGINEERS

Grand Worthy Chief, W. S. Cadwell, Chicago, Ill.; sec., Thomas H. Jones, 244 Eighth street, N. E., Washington, D. C. Next convention, Buffalo, N. Y., August 2-5, 1910.

AMERICAN ORDER OF STEAM ENGINEERS

Supr. Chief Engr., Frederick Markoe, Philadelphia, Pa.; Supr. Cor. Engr., William S. Wetzler, 753 N. Forty-fourth St., Philadelphia Pa., Next convention, Philadelphia, Pa., June 6-10, 1910.

NATIONAL MARINE ENGINEERS BENEFICIAL ASSOCIATIONS.

Pres., William F. Yates, New York, N. Y.; sec., George A. Grubb, 1040 Dakin street, Chicago, Ill. Next meeting, St. Louis, Mo., January 16-21, 1911.

OHIO SOCIETY OF MECHANICAL, ELECTRICAL AND STEAM ENGINEERS

Pres., O. F. Rabbe; sec. and treas., Prof. F. E. Sanborn, Ohio State University, Columbus, Ohio. Next meeting, Cincinnati, May 19 and 20, 1910.

INTERNATIONAL MASTER BOILER MAKERS' ASSOCIATION

Pres., A. E. Brown; sec., Harry D. Vaught, 95 Liberty street, New York. Next meeting at Niagara Falls, Canada, May 24-27, 1910.

INTERNATIONAL UNION OF STEAM ENGINEERS

Pres., Matt. Comerford; sec., Robert A. McKee. 606 Main St., Peoria, Ill. Next convention, Denver, Colo., September, 1910.

NATIONAL DISTRICT HEATING ASSOCIATION.

Pres., A. C. Rogers, Toledo, O.; sec. and treas., D. L. Gaskill, Greenville, O. Next annual meeting at Toledo, O., May, 1910.

Moments with the Ad. Editor

A department for subscribers edited by the advertising service department of Power and the Engineer.

With this issue this Department celebrates its fifteenth birthday.

It is fifteen weeks old. Quite some youngster! And among other traits it has developed a natural bump of curiosity as to how it has been received.

Its infantile bugaboo has been the "thumbs down" sign. For it's quite a thing to force oneself, unasked, upon a cold, matter of fact, bustling world, and "make good." And back of its smiling exterior has been the thought—"I wonder what they think of me?" Which was recently answered in the following manner:

At a dinner, given recently, were quite a goodly gathering of operating engineers, chief engineers of plants and a number of manufacturers. During the general talk one of the men remarked that there were now two pages in POWER which alone were well worth the subscription price, even if a man did not read any of the rest of the paper—

The first reading page in the paper (the big-type editorial page). And "MOMENTS WITH THE ADVERTISING EDITOR."

This remark brought forth similar comments from others, and a general discussion followed, which brought out the fact that the *majority of those present always read the Advertising Page.*

Now this banished the "bugaboo" to the dark pit and made this Department feel that maybe it *was* welcome, and appreciated.

But are we going to perch upon a high pinnacle and crow?

Nay, verily! For fifteen weeks is hardly a ripe old age, and there's a long path ahead of us. And by saving our breath we may become better and gain in strength. For as we live, we learn.

* * * * *

People take a remarkable interest in advertising of all kinds these days.

We are all eager to read about "the largest advertisement in the world," or "the most expensive," that the newspapers tell about every little while.

And when we hear that a big champagne company is spending $50,000 for a new electric sign on the Great White Way or that a manufacturing concern is taking a $6000 "spread" in a certain general publication of immense circulation, we are properly impressed.

But what we want to remember is that while these facts are interesting, they affect *us* not in the slightest degree. The advertisements that mean most to the engineer or the machinist or the electrician are right in his own paper. There he'll find the ads of products that will help him to do his work better, to do it easier and that will mean savings for his employer and another step up the ladder for himself.

* * * * *

"There is just *one* way of staying abreast of the times in power-plant equipment," said the Boss from the Big Factory in the Nearby City. "Keep your ear *everlastingly* to the ground for the *first* rumble of Better Equipment for the Plant.

"Don't imagine that you can stay in the front, in this day and generation, by taking stock, *once a year*, of the improvements of the past 12 months. If you do, you'll probably discover that the Other Fellow has gained a few laps on you. Things move too fast.

"And it's right here that good, live trade papers have conferred one of their greatest boons. I read the advertising pages of POWER *every week*, because it's the one best way of keeping in live touch with the best that the market affords in power-plant equipment.

"I learned long ago that no successful power-plant man could afford to neglect the *new* things. It's well enough to be conservative, but there are too many good minds constantly striving to improve all kinds of power-plant equipment, for the best of *last* week to be invariably the best of *this* week. Competition is too keen to *follow on behind* in any improvement."

* * * * *

The advertiser cannot afford to lie—or to fool—or to waste time. He has too much at stake. Hence you won't find any articles, any tools, any power-plant devices which will not bear thorough investigation among the "articles advertised." Suppose a man were to lie to you or to fool you, once—you wouldn't hold out the glad hand of welcome when he came around again, would you?

There's the principle.

An advertiser who advertised anything but the straight, cold, hard facts about his goods would not get a hearing for any length of time.

Yet—note this—these advertisers in your paper are with us week after week, have been with us for years, you recognize them as friends as soon as you turn to the advertising pages. And the fact that they can afford to advertise in your paper for so great a length of time is mute evidence that the goods they tell you about have an interesting story that loses nothing in the telling, no matter how often. Goods which will bear the closest scrutiny, the most detailed investigation, and hold their own. Goods which you can use with perfect assurance of securing "value received."

BUSINESS ITEMS

The Vilter Manufacturing Company, Milwaukee, Wis., report 14 recent contracts for Corliss engines and refrigerating machinery.

The office of Whitney & Underwood, consulting engineers, formerly located at 143 Liberty street, New York, has been removed to 140 Liberty street.

The York Manufacturing Company, York, Penn., manufacturers of ice-making and refrigerating machinery, have received 38 recent orders aggregating 1053 tons of refrigeration.

At Missouri Valley, Iowa, the Missouri Valley Electric Light Company has just installed a 500-kilowatt Westinghouse turbine generator set for furnishing local light and power. The turbine is of the complete expansion type, utilizing steam at 125 pounds and exhausting into a vacuum of 28 inches.

The New Era Gas Engine Company, of Dayton, Ohio, has recently sold out its autocycle business, and with it the entire plant and equipment, except such tools and appliances, patterns, etc., that were only adapted to the gas-engine business. They have interested a large amount of new capital, and are now planning to equip a new factory for the exclusive manufacture of their "New Era" gas and gasolene engines. Catalogs and prices are wanted on all sorts of small tools and appliances.

The Schaeffer & Budenberg Manufacturing Company has removed its Western department to new offices in the Manhattan building, 315 Dearborn street, Chicago, Ill. This office looks after all business originating in Michigan, Indiana, Kentucky, Tennessee and all States lying west to the Rocky mountains. The Western management is in the hands of W. H. Shenton, with J. Nienhouse, assistant, and their association of over 15 years with the company in this field assures to customers the best possible attention to all inquiries and orders.

Recent installations of the Ray automatic system of purifying boiler feed water, are reported as follows: Hydraulic Press Brick Company, St. Louis, Mo., fifteen machines; Barber Asphalt Company, Des Moines, Iowa, three machines; Public Water Works, Pueblo, Colo., one machine; Old Dominion Mining Company, Joplin, Mo., one machine; Whitewater Mill and Elevator Company, Whitewater, Kan., one machine; Omaha Packing Company, Omaha, Neb., one machine; Moses Brothers, Great Bend, Kan., two machines; Monarch Portland Cement Company, Humboldt, Kan., eight machines; Wisconsin Zinc Company, Platteville, Wis., four machines. The Ray system is made by the Ray Steam Specialty Company, 1908 Wyandotte street, Kansas City, Mo.

The average factory buys a large amount of belting each year, which is chopped up and put on various machines as belting gives out. Few plants keep any record of the actual length of service of the belts on any particular machine. At the end of a year's time, it is not definitely known whether the belt equipment for the various kinds of machinery in the shop has cost more than it should or not. We believe that our readers generally will be interested in a plan of keeping shop records which has just been gotten out by the engineers of the New York Leather Belting Company, 51 Beekman street, New York City. Charts have been printed, which can be tacked up on every floor in a factory and by merely filling in certain blanks, entailing little or no trouble, at the end of the year the exact record of belts on every machine on that floor can be absolutely checked up. These charts may be had by applying to the above company.

NEW EQUIPMENT

Lewis Bros., Newark, N. J., will install a new refrigerating system.

The Ajax-Grieb Rubber Company, Trenton, N. J., will increase its power plant.

Seidenberg & Co., Trenton, N. J., is to increase the capacity of its power plant.

The city council of Keewatin, Minn., is considering the installation of an electric-light plant.

The town of Minnedosa, Man., is preparing to call for tenders for the construction of a hydroelectric power plant.

Andrew Stangle, general manager of the Idaho Butchering and Packing Company, Buhl, Idaho, will erect an ice and refrigerating plant.

The Lon de Van Mining Company, of Juneau, Alaska, is to install a power plant at mines on Georges Inlet. Otto Lonstrop is general manager.

The Northwestern Mutual Life Insurance Company, Milwaukee, Wis., is to build a $2,000,000 office building with separate heating and power plant.

The Marshalltown (Iowa) Power and Light Company contemplate installing additional equipment, including two 350-horsepower boilers, also stokers.

The Neptune Ice Company, 100 William street, New York, will erect a 200-ton ice plant on Neptune avenue and Twenty-third street, Coney Island, N. Y., to cost $75,000.

J. T. Joyce, of Eau Claire, Wis., and D. Buchanan, of Chippewa Falls, are interested in a company formed for the purpose of developing power sites along the Chippewa and Flambeau rivers.

The Madison (Wis.) Cold Storage Company, with a capital stock of $200,000, is being financed. Proposed plant is to be entirely modern in equipment, with a capacity of 1,000,000 cubic feet.

Sealed proposals will be received until 12 o'clock noon, May 20, for furnishing an electric-light system at Fort Missoula, Mont. Information can be had of Major A. B. Shattuck, constructing quartermaster.

Sealed proposals will be received until 1:30 p.m., May 23, for the construction of an electric-lighting system at Fort Morgan, Ala. Information can be had of Capt. H. B. Chamberlain, constructing quartermaster.

The Schwarzschild & Sulzberger Company has commenced the erection of a new $3,000,000 packing plant at Oklahoma City. The power house, with an engine room of 50x100 and boiler room 50x150, will have a chimney 250 feet in hight.

Sealed proposals will be received until 3 p.m., May 25, for furnishing and installing an electric power plant and electric-lighting system at Fort Caswell, N. C. Information can be had of First Lieutenant W. R. McCleary, constructing quartermaster.

Proposals will be received until 3 p.m., June 13, at the office of the supervising architect, Treasury Department, Washington, D. C., for the installation of a new high-pressure steam-boiler plant and accessories for the United States court-house and postoffice building, at Pittsburg, Penn.

Sealed proposals will be received at the office of the consulting quartermaster, Fort Dupont, Delaware City, Del., until 11 a.m., May 23, for two 75-horsepower water-tube boilers, one feed-water heater, one feed pump, new steam and exhaust mains. Plans and information can be obtained of the quartermaster.

Tenders will be received until May 16 for the Winnipeg (Man.) electrical-distribution system for the following items: No. 51, conduit; No. 52, construction conduit runs 15[illegible]; No. 53, substation transformers and switching apparatus. Plans and copy of tenders can be obtained at the engineer's office, Carnegie library, Winnipeg, Man.

NEW CATALOGS

S. F. Bowser & Co., Fort Wayne, Ind. Folder. Lubricating oil storage. Illustrated.

Morris Machine Works, Baldwinsville, N. Y. Catalog. Centrifugal pumping machinery. Illustrated, 96 pages, 6x9 inches.

The Vilter Manufacturing Company, Milwaukee, Wis. Catalog. Corliss engines. Illustrated, 78 pages, 6x9 inches.

Clement Restein Company, Philadelphia, Penn. Catalog No. 3. Belmont packing. Illustrated, 160 pages, 6x9 inches.

B. F. Sturtevant Company, Hyde Park, Mass. Bulletin No. 176. Steam turbines. Illustrated, 16 pages, 6½x9 inches.

The General Specialty Company, 885-895 Niagara street, Buffalo, N. Y. Pamphlet. "Pictorial Proof." Tube cleaners. 7x11 inches.

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Advertisements under this head are inserted for 25 cents per line. About six words make a line.

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